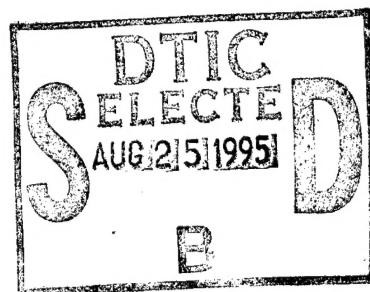


NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

EVALUATING FOREIGN-SOURCE
DEPENDENCIES IN U.S ARMY
MISSILE SYSTEM PRODUCTION

By

Sergio Pena

March, 1995

Thesis Advisor:

David F. Matthews

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**EVALUATING FOREIGN-SOURCE
DEPENDENCIES IN U.S. ARMY
MISSILE SYSTEM PRODUCTION**

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B.B.A., University of Texas at Austin, 1981**

Submitted in partial fulfillment
of the requirements for the degree of

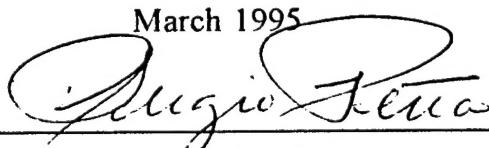
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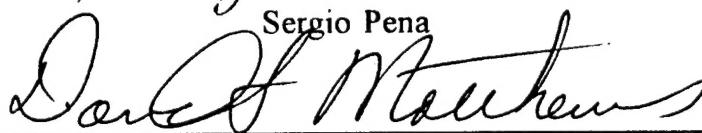
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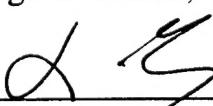
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ABSTRACT

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to inform the Government acquisition community concerning this country's dependence upon foreign sources for both components and technologies used in the production U.S. Army missile systems. The intent of this thesis is to increase the awareness level of acquisition managers on this issue. The increasing reliance on foreign sources raises the question of the defense industry's prompt access to required foreign-made products, or materials, during times of surged production. This thesis will provide an objective analysis of the Department of Defense's (DoD's) vulnerability to major disruptions in the production of critical components, especially for Army missile systems, in the event of a foreign source being lost. Government acquisition managers could use this thesis as an aid when analyzing alternative solutions to their foreign-source dependency problem.

The growing defense industry dependence on materials and products from foreign countries will be reviewed. The dependence ranges from relying entirely on imported raw materials, to using foreign-made electronic components in high-tech weapon systems. This thesis will also provide information on the types of foreign-source dependencies.

Numerous studies have been performed in recent years, resulting in an abundance of literature that addresses the mushrooming dependence of U.S. defense contractors on foreign sources. The primary focus of issues dealing with the defense industrial base's reliance on foreign sources has been at the national level, with recommendations aimed at improving productivity, incentivizing industry, managing industrial preparedness, improving strategic stockpiles, and on other necessary actions. These measures, although essential, do not give attention to the need to integrate the efforts of the Program Management Offices involved in the initial development and management of defense systems. This thesis will research the acquisition process from the points of view of economists, the U.S. Government acquisition community, and the defense industry to determine the extent foreign-source use and the solutions being considered.

Many DoD exercises and mobilization studies conducted during the 1980's warned that the U.S. was not prepared to fight any war of consequence. During the 1980's, America faced one large, principal threat, the Soviet Union. There is a new threat environment in the 1990's, and this new threat involves the likelihood of future conflicts occurring with little warning. Regional conflicts that threaten the U.S. today could still consume vast quantities of munitions, parts, and weapon systems.

How this dilemma affects Program Managers (PM's) is a major concern. It is the PM's responsibility to oversee industrial preparedness planning, including foreign-source risk assessments. However, he or she is often not given the tools needed to discharge that responsibility. Despite the clear intent of Government policies and regulations to consider foreign-source dependencies in the early stages of the acquisition cycle of a weapon system, it is very difficult to find any acquisition program document that identifies the operational requirements and estimates the industrial capability needed to support that weapon system. [Ref. 1]

America's dependence on foreign sources has drawn much attention since the 1980's. Figure 1 shows a political advertisement by the Fiber, Fabric and Apparel Coalition for Trade. The coalition tried to get protection for domestic producers of boots, uniforms and helmets, and to avoid what they claimed was a dependency on foreign sources. This thesis will identify analytic tools that can assist Government acquisition managers, including Army PM's, in determining where dependencies exist and if they are unacceptable.

B. IMPORTANCE

One of the primary national objectives mentioned in the 1994 National Security Strategy (NSS) is the enhancement of U.S. security by deterring aggression. Maintaining a strong defense capability is cited as "critical to the success" of this aim. Dealing with major regional contingencies (MRC's) is noted as a task that must be accomplished in order to "protect and advance U.S. interests." In addressing MRC's, the NSS states:

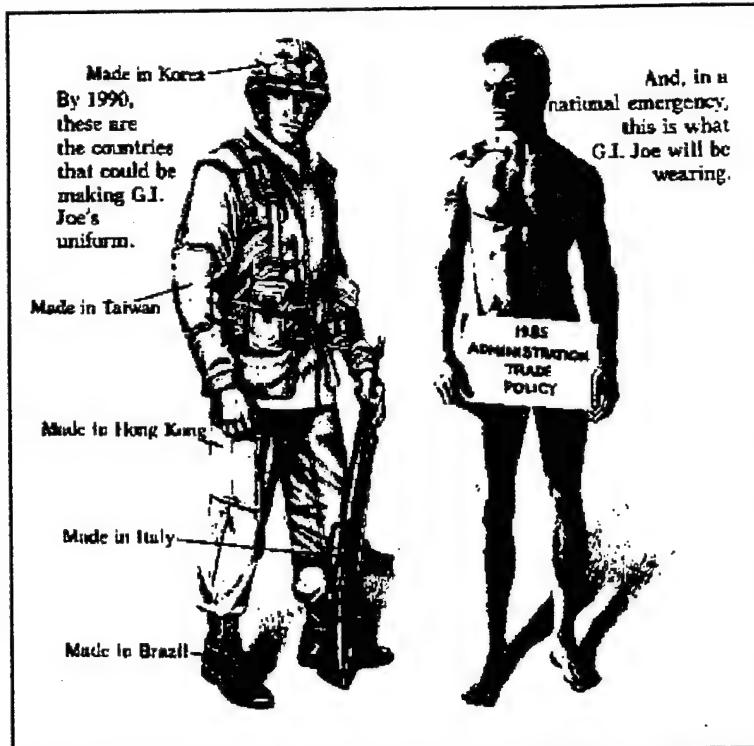


Figure 1 Advertisement by the Fiber, Fabric and Apparel Coalition for Trade that Appeared in the Washington Post, November 21, 1985

To deter aggression, prevent coercion of allied or friendly governments and, ultimately, defeat aggression should it occur, we must prepare our forces to confront this scale of threat, preferably in concert with our allies and friends, but unilaterally if necessary. To do this we must have forces that can deploy quickly and supplement U.S. forward based and forward deployed forces, along with regional allies, in halting an invasion and defeating the aggressor.

With the increasingly globalized economy and the reduction of the domestic defense industrial base, foreign sources will continue to be used in both the commercial and defense industrial sectors. There are some benefits to the use of foreign sources, and not all uses of foreign sources constitute risks to national security.

To further complicate this issue, research indicates that the DoD does not know the full extent of the use of foreign-made items in its weapon systems. In addition, DoD

has neither a reliable system to identify foreign-source dependencies nor a system to minimize unacceptable dependencies.

According to the General Accounting Office (GAO), as the defense budget is reduced, policymakers face a number of critical issues related to both preserving technological leadership and ensuring the existence of the industrial base capabilities required to meet the national security needs. One of these critical issues is the reliance upon foreign sources for critical technology and products to meet defense needs. [Ref. 2]

As recently as Operations Desert Shield and Desert Storm, the use of foreign sources for vital components in key weapon systems, especially Precision Guided Munitions (PGM's), was questioned. Government and industry faced some problems during the Gulf War in obtaining key components for essential weapon systems from foreign sources, especially Japan. The Bush Administration made nearly thirty requests to foreign governments during the war for key parts. [Ref. 3] Adding to the criticality of this issue, the Gulf War was fought with weaponry using technology often two decades old. The next generation of weapon systems to be developed will use more advanced technologies. This thesis will show that advances in technology add to the risks associated with relying on foreign sources and increase the need for U.S. Government management of the problem. In the article, *The Japan That Can Really Say No*, Ishihara Shintaro, writes about the Persian Gulf War:

What made pinpoint bombing so effective was PTV, a high-quality semiconductor used in the brain part of the computers that control most modern weapons. There were 93 foreign-made semiconductors in the weapons used by the United States. Among them, 92 were made in Japan. America...depended on foreign technology to carry out its war strategy.

[Ref. 4]

A key lesson from Operation Desert Storm was that conflicts can break out with little warning. To ensure continuous readiness in a time when the defense industrial base is shrinking and there is no global threat, the United States must place a greater emphasis

on industry's ability to gear up production lines quickly. There is no doubt about the need for a strong, healthy industrial base. Secretary of Defense William J. Perry noted in a paper issued on February 9, 1994, that "with a procurement budget that has declined more than 60 percent in real terms since fiscal 1985, the nation no longer can afford the luxury of maintaining a totally unique defense industrial base." The concern lies in its vulnerability as a result of being dependent on foreign sources, and developing a policy which ensures deployed forces have the staying power to avoid defeat. [Ref. 5]

The dependence on foreign sources for critical parts and equipment can cause delays from several months to years. These delays have the potential to affect the course of military combat operations. Former Secretary of Defense Caspar Weinberger has stated:

In those cases where our national interests require us to commit combat forces, we must never let there be doubt of our resolution. When it is necessary for our troops to be committed to combat, we must commit them in sufficient numbers, and we must support them as effectively and resolutely as our strength permits. When we must commit our troops to combat, we must do so with the sole object of winning... [Ref. 6]

The apprehension caused by the dependence on foreign sources is not hypothetical. Since World War II, there have been several instances of a national government trying to influence or coerce the actions of another sovereignty by withholding supplies or by issuing orders to foreign subsidiaries of domestic firms. For example, MITI, a Japanese governmental agency, forced a U.S. subsidiary of a Japanese company to withhold its advanced ceramic technology from the U.S. Tomahawk missile program to protest the use of nuclear weapons. [Ref. 7] More examples which are cited later in this thesis illustrate the consequences of foreign-source dependence. With the decline of Cold War solidarity, a growing number of political parties in the legislatures of our allies have more leeway to deny the U.S. access to technology, or supplies, or to dictate conditions for further support.

Initial inquiries into the issue of foreign-source dependency does not appear to be a major concern to most of DoD PM's or defense contractors. The lack of DoD emphasis on both the foreign content in its weapons systems and on data collection concerning the use of foreign sources has contributed to the general lack of acquisition community awareness. In short, research shows that DoD PM's are generally unaware of the foreign sources used in the design and production of their weapon systems. One study found that eight of the 13 major weapon systems examined were so dependent on foreign sources that periods from four to 24 months would be necessary for domestic firms to replace them. Therefore, acquisition officials must become more cognizant of the foreign dependency issue and be well prepared to identify, evaluate and manage foreign-source dependencies and the associated risks. [Ref. 8]

C. PRELIMINARY SUMMARY

Research shows that the DoD depends on foreign suppliers, particularly Japanese firms, for a growing number of state-of-the-art components. Many in both Government and industry believe that the reliance on imports signifies a broader problem. The decline of this country's high-tech industrial base could prevent the U.S. attaining victory in future conflicts.

The number of domestic prime and lower-tier defense contractors is diminishing. Capital investment among defense contractors trails that of the commercial sector by as much as fifty percent. As defense contractors go out of business, more of the vital defense technologies are being bought from foreign sources. Some key defense systems are so dependent on foreign-made components that any production surge would be directly proportional to the foreign sources' ability and willingness to provide those items.

The U.S. leads the world in many technologies which are used in the production of PGM's. However, investigation of some weapons systems, such as the Patriot Missile System, reveal a foreign presence. Therefore, the dependence on foreign sources for critical components in the production of PGM's is enough to merit an increase of awareness in the acquisition community.

Many ways have been suggested to confront the foreign-dependency issue. The consensus of opinion is that the Government must play a more active role. For example, DoD must establish a system of collecting data concerning the use of foreign sources in production of its weapon system. Presently, there are numerous laws and regulations which address the problem. However, there are questions concerning their comprehensiveness as well as to what extent they are being applied. Although PM's are required by policy and regulation to manage their system's dependency on foreign sources, they are often not provided with the necessary data and funding to meet this requirement.

A general climate exists in the Government which makes both the identification and management of foreign-source dependencies of secondary priority to cost and performance. Research indicates that PM's find themselves reacting, as several did during Operation Desert Storm, to the denial or delay of critical items for their weapon systems rather than executing emergency plans.

An economic model used in the past for antitrust studies provides an effective guide in determining whether a dependency on a foreign source for an item should be considered unacceptable. This model focuses on the concentration of suppliers and not the extent of foreign source use. According to the model, even the total use of foreign suppliers by the U.S. would not be an unacceptable situation if the sources were dispersed in sufficient different countries and firms. The model asserts that if the largest four firms, or countries, control more than fifty percent of a market, they possess the ability to coordinate denial, or delay, of critical items. Japan dominates several of the electronic industries that supply many of the critical components used in the production of high technology weapons, such as Army missile systems.

D. SCOPE, LIMITATIONS AND ASSUMPTIONS

This thesis will examine the foreign-source dependency issue and its importance to U.S. Army missile system design and production. The foreign-dependency problem is not new. To demonstrate that this issue is not hypothetical, this thesis will present

historical examples of one country's actions being dictated by another's by means of the denial of critical resources. In addition, this thesis will examine other countries' experiences with some of the solutions presently under consideration in the United States.

The issue will be reviewed from an economic viewpoint. The foreign-dependency problem is one of the three principal issues threatening U.S. economic security. The other two threats are the decline of the industrial base and the loss of industrial competitiveness. All three threats are distinct, but do have some overlap.

This thesis will review applicable Government regulations which require the management of foreign-source dependencies and determine if Army Program Managers' responsibilities are defined. In addition, this thesis will provide an estimate of the level of visibility PM's have into their systems' contractor base. This thesis will compare actions required by regulations to currently accepted practices among PM's and contractors.

The industrial base is composed of three distinct segments: prime contractors, subcontractors, and lower-tier suppliers. Each segment has different viewpoints. It is the lower-tier suppliers which most frequently use foreign sources. This thesis will examine each segment to determine if Government regulations contribute to the use of foreign sources.

DoD's reliance on foreign sources has received much attention at the national level, but relatively little at the working level, such as the Program Management Office. This thesis will examine the issue from the national to the PM level.

This thesis will review models and methods that Government acquisition officials can use to evaluate the acceptability of foreign-source use and propose a definition of what constitutes an unacceptable foreign-source dependency. The attributes of alternative remedies being considered by economists and Government officials will be examined.

A major assumption used in this thesis is that the globalization of the defense industry will continue, for the U.S. cannot dominate in every industrial sector. The scenario that this thesis will focus on is the U.S. having to fight in an MRC with little or no warning, for it is assumed that in this situation the defense industrial bases's

reliance on foreign sources will be the most conspicuous. It is also the scenario envisioned as the most likely by defense planners considering today's new threat environment. In the MRC scenario, it is assumed that production will only surge.

E. RESEARCH QUESTIONS

The primary research question is as follows: "What is the extent of unacceptable foreign-source dependencies in the production of U.S. Army missile systems that threatens the industrial base's ability to reach the Army's missile system production goals in the event of surge or mobilization?"

Subsidiary research questions are as follows:

- What is the extent of the use of foreign sources in the production of Army missile systems?
- What constitutes an unacceptable foreign-source dependency?
- What are the Department of Defense policies, directives, and guidance statements that are supposed to minimize or eliminate unacceptable foreign-source dependencies?
- To what extent does the foreign-source dependency problem receive visibility by Program Management Offices?
- What are the causes of the dependence on foreign sources?

F. LITERATURE REVIEW AND METHODOLOGY

A literature review was conducted of existing U.S. Government acquisition laws, regulations and policies concerning the use of foreign sources. In addition, the literature review included an examination of economic models or solutions written by experts on foreign-source dependency. Numerous articles in business periodicals concerning this issue were reviewed. Available literature concerning the use of foreign sources from the viewpoint of industry was also researched. U.S. Government publications, such as the Production Base Analysis, and reports from the General Accounting Office and the Office

of Technology Assessment, provided detailed information about the topic. Interviews of U.S. Army Program Managers and their staffs provided information on the adequacy of policies and practices used to minimize offshore dependencies. Executives of selected businesses involved in the production of Army missile systems were interviewed to estimate the extent of their use of foreign sources. The interviews of these business executives also provided an insight into their views on their firms' ability to support Army requirements in the event of a surge.

G. DEFINITIONS

The industrial base is that part of the total privately-owned and government-owned industrial production in North America that is or shall be made available in an emergency for the manufacture of items required by the U.S. armed forces and selected allies. A foreign source is any source of supply or manufacture outside the North America. Foreign dependency is an immediate, serious logistics support problem affecting the combat capability of the U.S. caused by the unavailability of a foreign sourced item.

Surge is the accelerated production, maintenance, and repair of selected items, and the expansion of logistics support services to meet contingencies short of a declared national emergency utilizing existing facilities and equipment. Only existing peacetime program priorities will be able to obtain materials, components, and other industrial resources necessary to support accelerated program requirements; however, increased emphasis may be placed on use of these existing authorities and priorities. Mobilization is the act of preparing for war or other emergencies through assembling and organizing national resources; and the process by which the armed forces or part of them, are brought to a state of readiness for war or other national emergency.

II. BACKGROUND

A. THE DEFENSE INDUSTRIAL BASE

1. Description

The defense industrial base can be viewed in three dimensions. The first dimension consists of the different tiers of contractors. The top tier contains large prime contractors which are typically highly dependent on Government contracts for survival. The second tier consists of subcontractors, many of whom produce subsystems or subassemblies, such as electronic devices, fire control computers and radars. The producers of components, such as semiconductors, and metal fabricators are at the lowest tier. There can be many subtiers of suppliers within the lowest tier. The number of subtiers will vary, depending on the each weapons system's peculiarities. A great deal of commonality exists between the defense and commercial industries at the lowest tier. The lowest tier is often referred to as the "dual-use" tier of the defense industry.

The second dimension is made up of the numerous sectors of the defense industry, such as aerospace, munitions, and missiles. Although many firms operate in several sectors, each sector can have different characteristics.

The third dimension is the mixture of ownership, private and public, in the defense industry which varies significantly from sector to sector. Figure 2 illustrates the make up of the industrial base as described here. [Ref. 9]

2. Chronic Defense Industrial Base Problems

A review of defense industry history reveals that many of the chronic problems experienced by the defense industrial base in the past are still evident today. Listed below are some of the most notable chronic problems that face the defense industry. Each problem will be addressed briefly.

- Extremely cyclical nature of defense procurements.
- Lack of structural planning.
- Inadequacy of industrial preparedness planning.

- Lack of actual industrial readiness.
- Importance of technology and research.
- Differences among defense industries.
- High concentration within industrial sectors.
- Heavy foreign dependence. [Ref. 10]

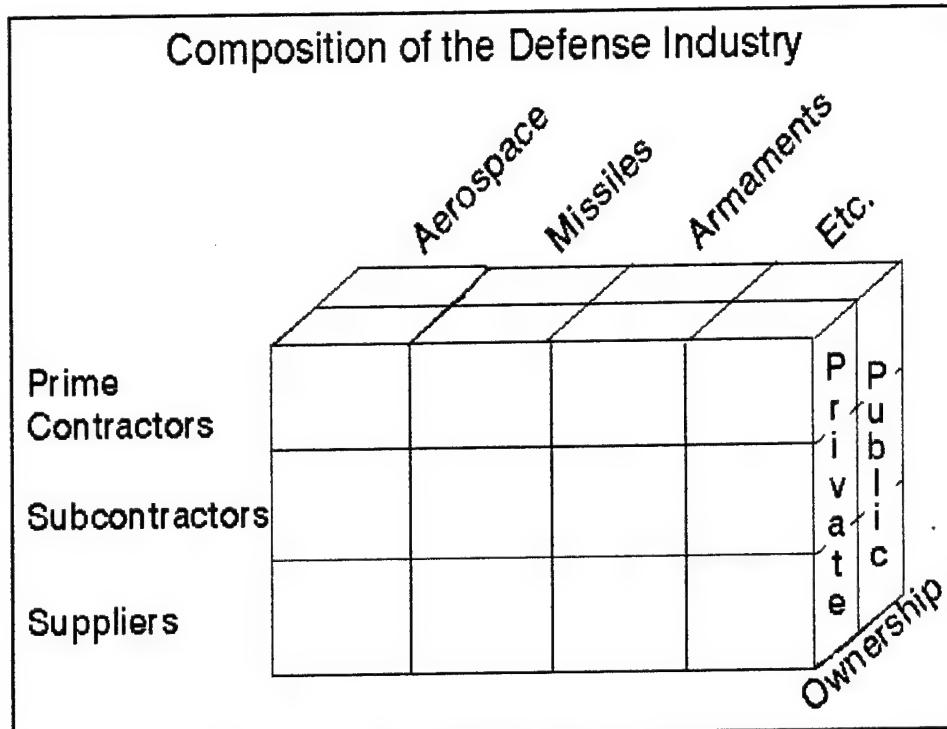


Figure 2. Composition of the Defense Industry

a. Extremely Cyclical Nature of Defense Procurements

Since 1776, the U.S. has increased defense expenditures significantly during times of crisis and followed with sharp reductions when the perceived threat declined. These reductions often lead to the breakup of the defense industrial base. Ironically, the basis for defense planning has frequently been the assumption of constant defense budgets. Figure 3 illustrates the cyclical nature of national defense budget authority from 1971 to 1997. [Ref. 11]

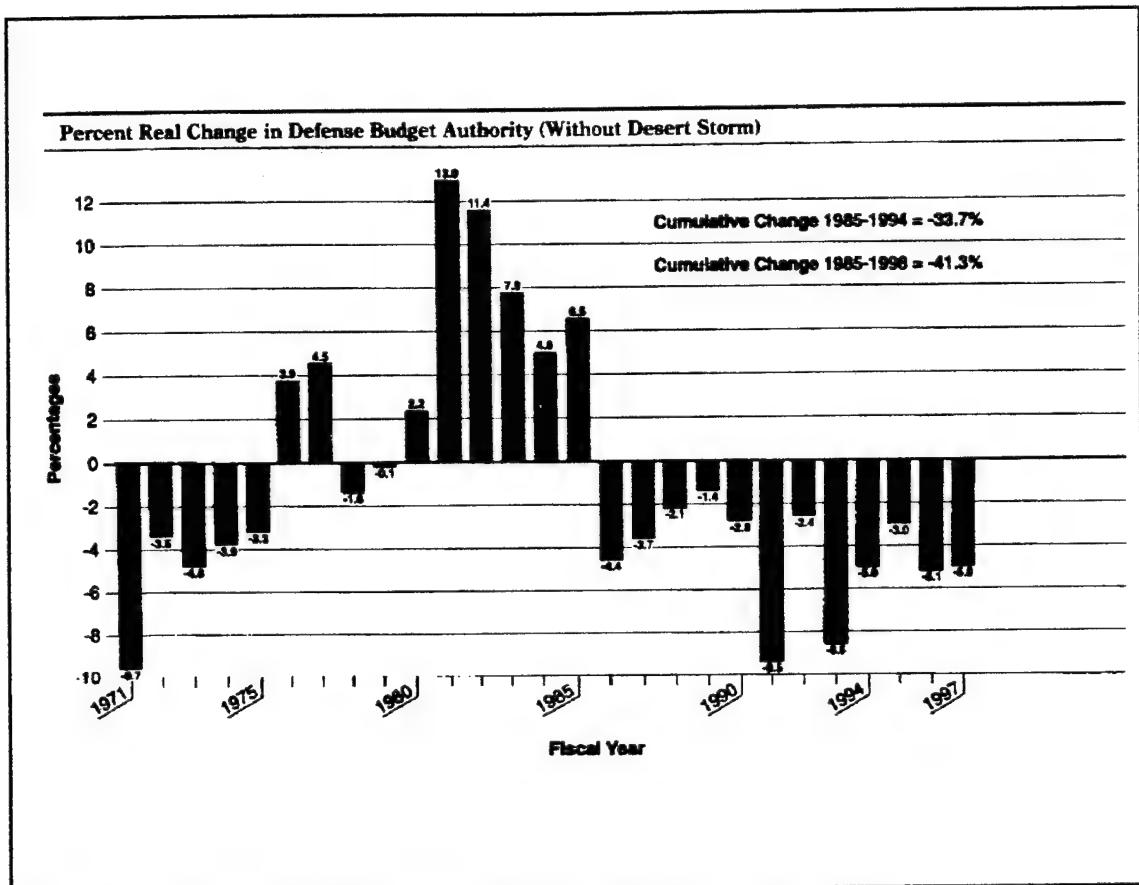


Figure 3. Percent Real Changes in Budget Authority, 1971-1997

b. Lack of Structural Planning

The evolution and status of the industrial base at any point in history has been based largely on chance. The determination of what is an adequate number of firms for each sector has never been performed in a systematic fashion. U.S. Government procurement regulations stress full and open competition, but what is an appropriate level of competition within the defense industry has not been determined. National policies have generally assumed that the defense industry's structural characteristics would be determined by the free market.

c. Inadequacy of Industrial Preparedness Planning

Historically, when an emergency has developed, there has been an absence of prior peacetime planning to meet the crisis. The result of the lack of industrial preparedness planning has been that in all of the wars in the history of the United States, the country has been able to mobilize men faster than its ability to equip them.

d. Lack of Actual Industrial Readiness

Today, high-technology weapons systems are of a more sophisticated nature, causing lead times for these items to increase. Many manufacturers operate near capacity, because excess capacity costs money and erodes profits. In peacetime, a company at the lowest tier could successfully supply defense contractors from several different sectors, or several contractors within a sector. This supplier could be overwhelmed by the simultaneous increase of competing contractor demands in the event of a national emergency. The result would be a "bottleneck" in the production flow.

e. Importance of Technology and Research

The U.S. has historically relied upon the technological superiority of its weaponry. This reliance places the greater emphasis on increased use of advanced technology to achieve maximum weapon system performance, rather than on quantity and cost. In addition, this emphasis encourages industrial management to focus on new systems under development as opposed to those already in production or deployed.

f. Differences Among Defense Industries

In spite of the differences between each of the defense industrial sectors, the Government continues to pursue a "uniform procurement policy" across all of these sectors. For example, ship building is a one-by-one process as opposed to munitions manufacturing which is a mass production operation. An industry-wide procurement policy ignores these differences.

g. High Concentration Within Industrial Sectors

Each cycle of rapid buildup and quick drawdown of the defense industrial base has contributed to defense business being concentrated among a few large firms.

The complex nature of the industry and the extensive capital equipment required to produce high-technology weapon systems have also added to this concentration.

h. Heavy Foreign Dependence

To keep the defense industry healthy, foreign countries have been relied upon both to provide critical supplies for weapon systems production and to purchase some of these systems. This reliance has increased in recent years.

3. Lessons Learned from Operation Desert Storm

The Army Logistics Evaluation Agency, the Logistics Management Institute (LMI), the Institute for Defense Analysis, and the Analytic Sciences Corporation each conducted studies for the U.S. Army on industrial base issues related to Operation Desert Storm (ODS). Their studies noted the following points:

- The industrial base response to ODS was successful largely because the operating, or "warm," industrial base had many of the required items and under production contract.
- Production of major end items was not accelerated (the Patriot and the Army Tactical Missile Systems were noted exceptions).
- The 6-month buildup period provided time for the limited industrial response.
- Production could not have met demand for many items, such as batteries and other electronic items, had the war been a longer one.
- There is a need to refocus industrial base planning. The immediate concern is the need to develop a crisis response orientation to handle MRC requirements.
- There is a Government need for industrial planning data.
- Industrial base responsiveness cannot replace war reserve stocks. Even with the buildup, many U.S. contractors could not meet surge requirements for selected items, especially electronics. [Ref. 12]

According to the LMI, the industrial base's response to ODS highlighted several key issues:

- The use of foreign-sourced components
- The limitations of industrial base planning
- The need for Defense Production Act authority (to be explained later)
- The lack of timely availability of additional procurement funds
- The limitations of emergency procurement actions by peacetime reprogramming authority.

The LMI study noted that the industrial base should not be expected to immediately eliminate stockage deficiencies if the production bases are cold. In addition, no formal planning system can fully identify the industrial base's capabilities. The nature of a "come-as-you-are" war meant that much of the detailed, formal Industrial Preparedness Planning performed in the past was not applicable. The LMI study mentioned that the U.S. Army Missile Command, as well as other commands, supported this point.

Most importantly, the LMI study noted that those with the most current and valid information on the industrial base during ODS were the Program/Project/Item Managers. The study noted that they "were the key to the pulse of industry's capabilities." [Ref. 13]

B. DEPENDENCE ON JAPANESE TECHNOLOGY

Japan plays a bigger role in today's American defense posture, because it controls a large portion of a very important resource - high technology. Japan's power is based in its commercial technology base. It has developed this base through a gradual process of adopting foreign technologies and constantly innovating methods of production. U.S. firms have invented more technologies, but Japanese have been more successful in manufacturing those technologies. For example, RCA Corporation, a U.S. company, invented the television, but Sony Corporation, a Japanese firm, perfected trinitron technology. [Ref. 14]

Since 1980, the Japanese share of patents awarded in the U.S. has grown dramatically. Japanese inventors received 22 percent of all U.S. patents in 1991 and 46 percent of all U.S. patents awarded to foreign firms, or people. [Ref. 15]

The U.S. reliance on Japanese semiconductors caused considerable concern in the 1980's and 1990's. From 1978 to 1986, the Japanese share of the world semiconductor market grew from 28 to 45 percent, while the U.S. share declined from 54 to 43 percent. By 1986, Japan had 65 percent of the world market in metal oxide semiconductor memories. In 1988, the Japanese Ministry of International Trade and Industry (MITI) reported that Japan would lead the U.S. in 11 of 41 high technology areas, while the U.S. would only lead in four. MITI reported that Japanese components were more reliable than their U.S.-produced counterparts in 27 of 41 areas and were equal in eight other areas. [Ref. 16]

The reliance on Japan for semiconductors has been heavily publicized in the media. During the Persian Gulf War, several Japanese electronics companies refused to provide American defense contractors with critical supplies. The *San Francisco Chronicle* reported that the Government "had to jump through hoops" to obtain critical Japanese-made components, notably batteries and semiconductors, used in a variety of weapons. The Japanese electronics companies were reported to have said they could not reduce existing contracts, such as orders from VCR, television and automobile manufacturers, to support deployed U.S. forces. Experts speculated that the companies probably were afraid of the domestic political ramifications of favoring military over commercial customers. [Ref. 17]

Japan's economy was less than 10 percent the size of the U.S. economy in 1960 and smaller than most of the major European economies. By 1991, it had grown to be the world's second largest economy with a gross domestic product (GDP) twice that of former West Germany and equal to nearly 42 percent of U.S. GDP. Since 1973, research and development (R&D) performance in Japanese manufacturing industries has grown at a higher annual rate than in the United States, and since 1980 faster than all

other industrialized countries. Japanese industry continued to expand its R&D spending through 1985, more than double the growth rate of the 1970's.

Japan's technological leadership is important to U.S. national security, because in recent years commercial technologies have advanced more quickly than military technologies. In the past, the requirements of military markets were stricter than the commercial markets. Military technologies used to be considered more advanced than commercial technologies. Commercial technologies were often "spin-offs" from military technologies. Today, commercial technologies lead in many areas, and military technologies are "spin-ons" from these commercial advances, such as in the area of microelectronics. In fact, military systems now use devices that are five to seven years out-of-date. U.S. and Japanese producers introduce new generations of devices every two to three years, while military systems evolve on five to 20-year cycles. Commercial markets in many high technology areas have the advantage of being bigger than military markets and producers are incentivized to conduct more R&D. In addition, the increased competition in the commercial marketplace puts a premium on improved reliability, greater endurance, more efficient manufacturing processes, and lower costs. The Defense Science Board reported that commercial electronic systems, such as computers and radios, were one to three times more advanced, two to ten times less expensive, five times faster to acquire and more reliable than equivalent military equipment. Japan's technological strength and the increasing importance of "spin-ons" to military weapon systems production will increase Japan's importance to DoD.

The U.S. Electronics Industries Association estimated that the electronics content of defense systems grew from 34 percent in 1981 to 40 percent in 1990 and will increase to 43 percent by the end of the year 2000. According to the DoD, Japan is significantly ahead of the U.S. in some segments of five of the 20 technologies that are critical to both national security and "the long-term qualitative superiority of U.S. weapon systems." The following is a list of the critical technologies in which the Japanese lead in some segments:

- Semiconductor materials and microelectric circuits

- Machine intelligence and robotics
- Photonics
- Superconductivity
- Biotechnology materials and processes [Ref. 18]

In 1980, the DoD and the Japanese Defense Agency (JDA) established the Systems and Technology Forum to examine ways that the U.S. and Japan could cooperate in military R&D, production and procurement. In 1983, the Japanese announced that the U.S. would be an exception to their country's military technology export ban. This enabled the export of Japanese technologies that could be used for military purposes. Since 1983, the DoD has sent a series of technology assessment teams to Japan to evaluate their technologies for potential military use. One of those teams cited the following sixteen primary areas of interest:

- Gallium arsenide devices
- Microwave integrated circuits
- Fiber optic communications
- Millimeter-waves
- Submicron lithography
- Image recognition
- Speech recognition/translation
- Artificial intelligence
- Electro-optical devices
- Flat displays
- Ceramics (for engines and electronics)

- Composite materials
- High-temperature materials
- Rocket propulsion
- Computer-aided design
- Production technology

From 1984 through 1986, other teams visited Japan to examine electro-optic, millimeter, microwave and manufacturing technologies. These efforts did not result in significant transfers of Japanese technologies to the U.S. This was largely because U.S. defense contractors were uninterested in Japanese technologies. In 1988, Japan proposed that the U.S. and Japan work together in R&D of five areas of military technology. In 1990, the two countries agreed to join forces in three of the five areas: ducted pocket technology (for rocket engines), hybrid seeker technology (for missiles), and closed-loop degaussing technology (for submarines).

Japanese technological leadership gives them more power within the international community in three respects. First, Japan will gain more leverage in the U.S.-Japan relationship as DoD's dependence on Japanese products and technologies increases, while JDA's reliance on U.S. technology correspondingly decreases. Second, Japan is now able to play a pivotal role in the global race for superiority in military technology. If Japan combines its strengths with those of the U.S., then the U.S. will enjoy unquestioned global superiority in military technologies. If Japan does not fully support the U.S. in the future, then U.S. technological superiority would be in danger. Third, Japan's technological and economic strength gives it the future ability to become a world military power in its own right. [Ref. 19]

C. PREVIOUS ATTENTION GIVEN TO THE FOREIGN DEPENDENCY ISSUE

In 1991, the Commerce Department and the Navy completed a three-year study tracing the sources of three major weapon systems: the HARM missile, the Mark 48 torpedo, and the Verdin Communications Device. Over 14,000 contractors and suppliers were examined. One finding was that 20 percent of the weapons systems' parts were made overseas.

In 1989, the Center for Strategic and International Studies noted that "the U.S. military's dependence on foreign suppliers was so acute that the United States could not support a war on the scale of the Vietnam conflict without rebuilding domestic capability." Most major U.S. weapon systems, and all PGM's, use foreign parts. An unexpected loss of foreign suppliers could stop PGM production for periods varying from weeks to more than a year. [Ref. 20] The Defense Science Board warned in 1987 that the "U.S. defense will soon depend on foreign sources for state-of-the-art technology in semiconductors." It called the situation "unacceptable."

It is characteristic of PGM production that the loss of any foreign component necessitates the production of its exact substitute by a domestic producer. In theory, if technological specifications are not known beforehand, the domestic substitution of non-specification items may create serious logistical and performance problems. This issue was noted in a 1985 report on the foreign-source dependency problem published for the Joint Logistics Commanders. The use of buffer stocks as both a measure of protection against the loss of a foreign source and as an alternative to mandating the exclusive use of domestic sources, is recommended by the Mobilization Concepts Development Center (MCDC). [Ref. 21]

D. TYPES OF FOREIGN-SOURCE DEPENDENCIES

The MCDC categorizes foreign-source dependencies into five groups:

- Subsystem dependencies are foreign-sourced items purchased directly by the prime contractor or an individually large item.

- Pervasive dependencies are common to many weapon systems, such as PGM's.
- Integrated Circuit (also known as semiconductor) dependencies.
- Individual dependencies are where a single system uses the foreign source.
- Mineral-based dependencies occur largely because the U.S. lacks certain types of minerals in sufficient quantity.

There are two principal types of subsystem dependencies: components purchased directly by the prime contractors and rocket motor cases. The dependency on foreign-made rocket motor cases occurs in several weapon systems. Of the five categories, subsystem dependencies would cost the most to rectify. A buffer stock costing almost nine million dollars would be required to buy enough subsystems to fill the gap between the loss of a foreign source and the availability of a subsystem from domestic sources. An MCDC study found that five major subsystems purchased for PGM's are in part foreign-sourced. Table I below lists those subsystems found to be foreign-produced and their producing countries. [Ref. 22]

Item(s)	Country	Months to Replace Source	Percent
Launch Tube	Israel	3	75%
Extrusion	Australia	2	Unknown
Actuator Motor	U.K.	3	60%
Gear Motor	U.K.	3	60%
Castings	Israel	3	50%

Table I. Foreign-Produced Subsystems

The most critical potential problems arise as a result of the loss of pervasive items, subcomponents that are common to multiple systems. A loss of foreign-sourced field-effect transistors (FET's) and ferrite cores could disrupt production on some items

for at least a year. The loss of gallium arsenide (GaAs) transistors, sapphires, and butane triol would have an impact of six months to a year. Precision glass and high-purity silicon could be produced in the U.S. easily without experiencing a significant disruption in production if foreign sources were lost, but the domestic producers' viability causes some risks to the producers. Some U.S. producers of transistors estimate that it would take more than a year to duplicate and prove some foreign proprietary transistor designs pervasively used in PGM's. Table II summarizes some of the pervasive dependencies.

[Ref. 23]

Dependencies on foreign-sourced semiconductors and integrated circuits are generic to all weapon systems and not only PGM's. The capacity exists in U.S. firms to produce semiconductors during a production surge. The heart of the dependency issue is that while most U.S. firms produce semiconductors, they use foreign firms for assembly and packaging due to their lower labor costs. Semiconductors intended for defense use are assembled and packaged in the U.S. in accordance with Military Specification 38510. The domestic capacity to assemble and package semiconductors to military specifications is insufficient to handle an industrial production surge.

Table III illustrates some individual dependencies. Ball screws, a noted Patriot Missile System foreign-source dependency, were previously coproduced by a U.S. and a British firm, but now only the British firm produces the items. The molybdenum foil listed below is used in the Patriot system and can be produced in the U.S., but the foreign foil costs less. [Ref. 24]

Mineral dependencies, most notably samarium, germanium, indium, and palladium, are the result of domestic mineral deficiencies. PGM demand for these minerals is modest. Industrial preparedness planners assert that the National Defense Stockpile would cover these deficiencies. [Ref. 25]

Item	Application	Source
FET's (Silicon)	High Frequency Radar	Japan
FET's (GaAs)	High Frequency Radar	Japan
Ferrite Cores	High Frequency Radar	Germany
Precision Glass	Target Detectors	Japan, Germany
Sapphire	Infrared	Switzerland
Butane Triol	Rocket Motors	Germany
High Purity Silicon	Target Detectors	Germany

Table II. Examples of Pervasive Dependencies

Item	Source
Ball Screws	U.K.
Copper Liner Forms	Switzerland
Molybdenum Foil	Austria
Printed Wiring Board Plating Bath	U.K.
Springs, Pivots	Germany, South Africa
Radome Chemicals	Germany, Mexico

Table III. Examples of Individual Dependencies

E. CONTINGENCY PLANNING IN THE 1990'S

1. Mid-Intensity Conflict and the Emergence of Regional Threats

For all its potential significance, the focus on mid-intensity conflict (MIC) is recent. Throughout the 1980's, the proliferation of low-intensity conflict in Central America and a hypothetical high-intensity conflict in Europe dominated U.S. military

planning. To prepare for combat in Europe, the U.S. spent billions of dollars to modernize its nuclear and non-nuclear forces. To fight Low-Intensity Conflicts (LIC's), DoD built up power-projection forces, that could be deployed around the world. These forces include the following: aircraft carriers, amphibious assault groups, light infantry units, and special operations forces. Military planners either considered MIC's insignificant or assumed that America's arsenal would suffice for any contingency.

As the 1980's ended, many military analysts began to worry about the threat posed by emerging regional powers. Although DoD continued to stress the Warsaw Pact and LIC's, it was evident that a war in Europe was the least likely contingency and that lightly armed forces intended for LIC's could be defeated by a heavily armed regional power.

The Commission on Integrated Long-Term Strategy, a high-level study group formed in 1988 by the Department of Defense and the National Security Council observed, "In the years ahead, many lesser powers will have sizable arsenals." Growing supplies of chemical weapons, ballistic missiles, and nuclear arms in the arsenals of these lesser powers, the commission warned, "will make it much riskier and more difficult for the superpowers to intervene in regional wars." As a result, "the U.S. ability to support its allies around the world will increasingly be called into question."

ODS initiated a new model for the U.S. military. While prior models for combat assumed that U.S. forces would fight the Warsaw Pact in Europe, or LIC in Central America, this model envisions periodic battles with well armed regional powers. To distinguish these conflicts from European high-intensity conflict or a Central American LIC, DoD officials categorize them as MIC's.

Like ODS, future MIC's are likely to be fast-paced and high-tech, involving unrestrained use of the most sophisticated weapons. Presently, the U.S. will fight regional powers using weapons designed for a war with the Soviet Union.

Although there is no obvious candidate for the "next Iraq," the perceived risk of MIC will likely persist for years. Some regional powers, such as Syria, Iran, Pakistan, and Brazil, harbor ambitions that could eventually lead to conflict with the U.S. Some

of these powers possess large, modern arsenals, including Weapons of Mass Destruction (WMD) with chemical, nuclear, and/or biological munitions.

According to a former Chief of Naval Operations, Admiral Carlisle Trost, in a statement to Congress early in 1990,

Today, developing countries are armed with 'First World' weapons. Proliferation of chemical weapons, growing access to nuclear weapons capability, and proliferation of cruise and ballistic missiles, submarines, and high-performance tactical aircraft mean that virtually any nation ... can bring capable and deadly weapons to bear.... The fundamental defense issue for the United States in the foreseeable future is to maintain a military posture that protects our interests and those of our allies from a diversity of regional threats. [Ref. 26]

2. National Strategy and Planning for Major Regional Conflicts

The National Security Strategy (NSS), published in 1993, states that the defense industrial base must be able to surge production prior to and during a contingency operation. In addition, the NSS addresses the need to examine the following:

- Projected trends in the industrial base's capacity to quickly surge production
- Critical industrial capabilities affected by changes in acquisition programs
- Allied potential to provide critical capabilities and how much the U.S. should rely on outside sources
- Technologies that may emerge which could offset the loss of critical component suppliers.

In 1993, the Secretary of Defense published the results of a Bottom-Up Review (BUR) conducted on DoD. The BUR noted the transition of dangers facing the U.S. from Soviet aggression during the Cold War to four categories of dangers in the post-Cold War era:

- The dangers from nuclear weapons and other WMD's
- Regional dangers primarily from large-scale major regional powers' aggression

- Dangers to democracy and reform in the former Soviet Union, Eastern Europe and elsewhere
- Economic dangers to U.S. national security

The focus for today, according to the BUR, is on the need to project power into regions important to U.S. interests and to defeat potentially hostile regional powers, such as North Korea and Iraq. ODS was such an operation.

Potential aggressors are expected to be capable of fielding military forces in the following ranges:

- 400,000 - 750,000 personnel
- 2,000 - 4,000 tanks
- 3,000 - 5,000 armored fighting vehicles
- 2,000 - 3,000 artillery pieces
- 100 - 200 naval vessels
- Up to 50 submarines
- 100 - 1000 Scud-class ballistic missiles, some with nuclear, chemical and/or biological warheads

The BUR used two scenarios for planning purposes: the North Korean invasion of South Korea and the Iraqi invasion of Kuwait. Both scenarios, known as Major Regional Conflicts (MRC's), assume that they will begin with little or no notice. The BUR called for the U.S. to fight two nearly simultaneous MRC's. Important to the examination of the foreign-dependency issue, are two BUR assumptions. First, that it may not be possible, prior to an attack, to reach a political consensus on the proper U.S. response. Second, due to the short-notice nature of future conflicts, the U.S. may be unable to convince its allies to cooperate. The U.S. must be prepared to conduct operations unilaterally.

Advanced munitions are listed in the BUR as an essential capability. The BUR states:

Precision-guided munitions already in the U.S. inventory...as well as new types of munitions still under development are needed to ensure that the U.S. forces can operate successfully in future MRC's and other types of conflicts. New smart and brilliant munitions under development hold promise of dramatically improving the capabilities of U.S. air, ground, and maritime forces to destroy enemy armored vehicles and halt invading ground forces, as well as destroy fixed targets at longer ranges, reducing the exposure to enemy air defenses.

Each MRC would require the following U.S. forces plus their supporting capabilities:

- 4 - 5 Army Divisions
- 4 - 5 Marine Expeditionary Brigades
- 10 Air Force fighter wings
- 100 Air Force heavy bombers
- 4 - 5 Navy Aircraft Carrier Battle Groups
- Special Operations Forces [Ref. 27]

III. LITERATURE REVIEW

A. THE EUROPEAN EXPERIENCE WITH FOREIGN-DEPENDENCY

Current studies of the U.S. industrial base warn that the lack of attention to the security aspects of globalization is unacceptable. However, an examination of alternatives within the context of the American experience is sketchy and incomplete. Cases from Europe, however, enable a richer and more profound examination of the foreign-dependency issue and available alternatives. During the past three decades, various European governments of differing ideologies have tried many of the major various solutions being considered in the United States. Lessons can be taken from these European experiences and applied to the foreign-source dependency problem facing DoD and Army policymakers.

1. Inherent Dangers with Globalization

All the major European powers have faced their own foreign-source dependency problems that were considered threats to their national security. In 1956, the U.S. threatened to order its oil companies to cut off supplies to the British and French if they did not withdraw their military forces from the Suez Canal. From 1964 to 1966, the U.S. withheld critical computer technology from France in order to stop the French hydrogen bomb development program.

In 1982, the U.S. response to the imposition of martial law in Poland was to suspend export licenses to the Soviet Union for a broad array of high technology goods. In addition, the U.S. prohibited both American subsidiaries and overseas licensees of American technology, from executing contractual obligations for sales to the Soviet Union. The Europeans faced foreign interference, imposed unilaterally by another nation, on the actions of firms operating on European soil with valid contracts. The British, German, and Italian governments reacted by ordering their own firms operating under U.S. licenses to proceed with shipments to the Soviet Union. The French government ordered the French subsidiary of Dresser, an American firm, to proceed with shipments of gas pipeline equipment to the Soviet Union. The resulting standoff put the American

subsidiary in France in the position of facing retaliation from a national government no matter how it acted. The European position prevailed.

Foreign subsidiaries of U.S. companies provided the U.S. government with influence in European governments' dealings with China, the Arab states, Cuba and the former Soviet Union. A noted economist and expert on the foreign-dependency problem, Theodore H. Moran, theorizes that the type of manipulation the U.S. employed upon other nations would be considered unacceptable if it were used against the United States. Moran further theorizes that the reason the U.S. has tended to dismiss the foreign-dependency threat is a "myopia" that is caused by America's atypical history since the end of World War II, during which the country had "the brief good fortune of finding that international liberalism and national hegemony spontaneously coincided." Moran argues that the reliance upon foreign technologies and sources can threaten national security.

The European experience also shows that the use of national "champion" industries, instead of foreign industries, does not completely remove the threat of foreign manipulation. First, the threat still exists if these industries rely on foreign sources for components or technologies used in the production of domestic final end-products. This is especially true if the sources are concentrated in one country, or if a monopoly exists in a foreign country. An example would be a U.S. prime contractor's subcontractor relying on foreign sources for semiconductors. Second, national firms may tend to pursue their own interests rather than the special interests of their home governments. In 1973, British Petroleum (BP) ignored the British governments' demands to increase oil deliveries to Britain during the Organization of Petroleum Exporting Countries' embargo. BP announced that it would place contractual obligations above national interests. National companies may also be increasingly vulnerable foreign manipulation as the degree of their own globalization increases. [Ref. 28]

2. Requiring Domestic Production and Technology Use

Requiring that production and key technology use be done on domestic soil was tried in Europe. This approach was initially undermined by the United States. The U.S. tended to place constraints on the activities of American subsidiaries in Europe and write prohibitions into international licensing agreements. European firms countered this U.S. influence by substituting European products for American ones when licensing agreements prohibited the use of U.S. technology. Rolls-Royce engines replaced Pratt and Whitney engines in military vehicles and Ferranti radars replaced Hughes radars when end-items were to be exported to countries forbidden by U.S. licensing agreements. What the Europeans learned from their experiences was that a strong bargaining position and ultimate protection did not result from a legal capability to exercise rights of sovereign jurisdiction over activity within their borders, but rather from arranging alternative suppliers, diversifying purchases, becoming cautious about using a single source of technology or equipment. [Ref. 29]

3. National Industrial Autarky

The Europeans learned about autarky, or self-reliance, in several of their key sectors. Economists were against a policy of autarky believing that it would cause inefficiency, lack of competition and loss of economies of scale. Those in favor of the policy proposed that a government could take a world-class company, ensure it an exclusive place in the home market, and provide it with abundant public resources in order to enable it to capture a sufficiently large global market to provide the needed economies of scale. The British government supported the corporate team of Hawker Siddeley Aviation, Marconi-Elliott Avionic Systems, and Rolls-Royce in their attempt to produce the Airborne Early Warning (AEW) Nimrod, a British competitor to America's Boeing Airborne Early Warning and Control System (AWACS). Each member of the team had a strong performance record and technological strength and the AEW had numerous advantages over the AWACS in cost and performance.

The failure of the AEW program illustrated the weaknesses of a national approach. The nature of the threat from the Soviet Union's Backfire Bombers changed as more was

discovered about their performance. The AEW program was unable to obtain multinational assistance when faced with quickly changing technological challenges. The result was not technological failure, but rather delays, cost increases and questionable upgrades of capability. When the Falklands Conflict began, the AEW was 18 months behind schedule and the British were without a sophisticated surveillance and fighter control capability against the Argentine air strikes. When faced with the decision between self-reliance and an exposed security position, the British cancelled the program. Boeing, in developing and producing the AWACS, centered its corporate strategy around building a multinational procurement consortium behind what was perceived as an American aircraft. [Ref. 30]

4. Lessons for the United States

The above examples illustrate that the potential risks associated with reliance upon foreign sources is not hypothetical. There are three lessons that the U.S. can take from the European with foreign-dependencies experiences:

- There are inherent dangers in the global nature of critical industries.
- The degree of foreign control is dependent upon the extent of external concentration in the industries which the defense effort depends, not the nationality of the firms themselves. The threat cannot be removed by just establishing national companies or requiring domestic production. Diversification and multiplication of the companies and locations offers the most dependable method for minimizing the threat of foreign control.
- National autarky, while appealing, has its own inherent dangers in terms of cost, schedule and performance. [Ref. 31]

B. THE GOVERNMENT'S VIEWPOINT, POLICY AND REMEDIES

The Government has given the foreign-dependency problem considerable attention at the national level. On June 3, 1994, President Clinton issued an Executive Order in which he stated the following policy:

The United States must have an industrial and technology base capable of

meeting national defense requirements, and capable of contributing to the technological superiority of its defense equipment in peacetime and in times of national emergency. The domestic industrial and technological base is the foundation for national defense preparedness.

The Executive Order requires the continuous evaluation of the capability of the domestic industrial and technological base to satisfy peacetime and emergency requirements. It specifically includes subcontractors and suppliers, materials, skilled labor, and professional and technical personnel. In the Order, the President directs the Secretary of Defense and the heads of other Government agencies to establish an information system on the domestic defense industrial base. The Secretary of Defense is also required by the Order to report to Congress on a strategic plan for developing a cost-effective, comprehensive information system capable of continuously identifying vulnerability in critical components and critical technology items. The Secretary of Defense must perform an analysis of the production base of not more than two major weapons systems of each service in establishing the information system. Each analysis shall identify the critical components of each system. The Secretary of Defense, in consultation with the Secretary of Commerce, and the heads of other Federal agencies will issue a biennial report on critical components and technology. [Ref. 32]

Since the early 1980's, DoD's policy has been to integrate industrial base considerations in the acquisition process for two reasons:

- Authority. The PM has the best visibility into a program's status and can control resources that can directly affect industrial base problems.
- Timing. The PM can best identify and implement measures to enhance industrial base capabilities early in the acquisition process when they are most effective.

According to the Defense Systems Management College (DSMC), PM's and other acquisition officials have expressed two consistent views of industrial base programs. First, these matters have secondary priority compared to design, cost, schedule and performance. Second, the PM Office has limited resources and must accomplish a large

number of objectives. In order to give the industrial base enough attention, PM's feel that they require additional resources, because the issues are complex and expensive to undertake. The reason for the apparent lack of PM responsiveness stems from a need for:

- Greater command emphasis
- Holistic program management
- Effective analysis tools and techniques
- Efficient data collection procedures. [Ref. 33]

DoD Directive 5000.2 establishes the core of fundamental policies and procedures that can be implemented down to the PM level. This Directive provides the basis for effective integration of defense industrial base considerations into the acquisition planning process. This Directive states the following policies:

- The industrial base implications of proposed defense acquisition program peacetime, surge, and mobilization objectives, to include conflicts with other DoD or commercial programs, shall be addressed at each milestone decision point.
- Program planning shall include procedures to identify and minimize the potential impact of foreign dependencies and diminishing manufacturing sources and material shortages on production and support objectives.

DOD Directive 5000.2 requires that program plans include procedures to identify and minimize potential foreign dependencies and diminishing manufacturing sources and material shortages. If foreign sources are used, the Directive states that program plans will describe actions to ensure their availability in peacetime and under surge conditions.

[Ref. 34]

DoD 4003.3-M states that planning should identify foreign sources who are defense suppliers to planned U.S. and Canadian producers. A revision to include Mexico as a result of the North American Free Trade Agreement has not been published. DoD Instruction 4005.3 states the following:

- DoD components will limit industrial preparedness planning to producers located in the U.S. and Canada.
- Planning will identify foreign dependency on items, components and/or materials that could impact on U.S. and Canadian producers during surge or mobilization. These dependencies will be reported and briefed in the Production Base Analysis.

DoD Directive 5160.54 states that it is DoD policy to have an emergency mobilization preparedness capability that will ensure that the Government, the private sector and the public can respond decisively to any national emergency. DoD Directive 4245.6 requires the development of a manufacturing strategy as a part of the program acquisition strategy. The Directive further directs that manufacturing deficiencies and foreign-dependencies on critical materials shall be addressed concurrently with concept demonstration and validation through the use of manufacturing technology projects or other means.

A manufacturing strategy must address any foreign-source dependencies. To avoid such dependencies, all acquisition/procurement strategies must consider the dependence on foreign manufacturing content as a decisionmaking criterion equal to cost, quality, and schedule. Implied in the above statement is the need for identification of foreign-source dependencies early in the acquisition process. Actions taken early in the process have the greatest affect on the problem. Surge and mobilization capabilities are required to be evaluated for Milestone II and III reviews. [Ref. 35]

The requirement and pressure for full and open competition is cited as one cause of the foreign-dependency problem. In many instances, it has been taken as a mandate to remove distinctions that consider the need for domestic production for national security reasons. The Federal Acquisition Regulation (FAR) specifically authorizes exceptions to full and open competition. However, research indicates that contracting officers often are not given guidance or clear criteria in using this exception. Partly to address the foreign-dependency problem, the FAR provides an exception to for full and open competition in contract awards when it is necessary to do one of the following:

- Maintain a facility, producer, manufacturer, or other supplier available for furnishing supplies or services in case of a national emergency or to achieve industrial mobilization.
- Establish or maintain an essential engineering, research, or development capability to be provided by an educational or other nonprofit institution or a federally funded research and development center.

Conditions where the FAR states that the above exceptions to full and open competition may be appropriate are listed below. This list is not complete, but contains only those applicable to the foreign-dependency issue.

- Keep vital facilities or suppliers in business or make them available in case of a national emergency
- Train a selected supplier in the furnishing of critical supplies or services, prevent the loss of a supplier's ability and employees' skills, or maintain active engineering, research, or development work
- Maintain properly balanced sources of supply for meeting the requirements of acquisition programs in the interest of industrial mobilization
- Limit competition to planned producers with existing industrial preparedness agreements under DoD Industrial Preparedness Program
- Create or maintain the required domestic capability for production of critical supplies
- Continue in production, contractors that are manufacturing critical items
- Divide current production requirements among two or more contractors to provide for an adequate industrial mobilization base. [Ref. 36]

The DSMC noted that a comprehensive analysis on foreign-dependency issues has not been performed on the defense industrial base. There are three principal reasons that there has not been such an analysis:

- The lack of viable production information on which to base decisions
- The lack of adequate analysis methodology to derive when a solution is required and to select the best solution

- The lack of specific guidance and monitoring by PM's and the Department of the Army regarding how to seek foreign-source dependency solutions. [Ref. 37]

C. INDUSTRY'S VIEWPOINT

The defense industry is critical to the nation's economy and security. In 1991, one of every ten production workers and one of every three engineers and scientists were in the defense industry. Several researchers refer to the defense industry as a "sick" industry. Defense firms operate in a weakening market with heavy debt, difficulty in borrowing, considerable excess capacity, low cash generation, increasing risks, old production equipment, insufficient capital investment, relatively low productivity, mixed quality, and rising prices.

Researchers have warned of growing problems at all levels of the defense industrial base. At the prime contractor level, researchers cite unhealthy financial conditions, aging plants and equipment, excess capacity, and the high cost of weapon systems. At the lower tiers, research shows increasing foreign-dependencies, a decreasing number of sources, and the development of bottlenecks. Even though defense budgets grew in the 1980's, conditions in the defense industry worsened by 1988. Studies indicate that DoD ignored the problems. Congress and DoD made a series of "attacks" on the defense industry as a result of the "waste, fraud, and abuse" attention in the media. These attacks intensified as the growth rate of defense budgets declined in the late 1980's. Since 1985, DoD attempted to shift the risk of budget actions to its industrial suppliers. A series of "industry bashing" actions, both legislative and regulatory, resulted in a deterioration of government-industry relations and had a significant financial impact on the defense industry. These actions included the following:

- A reduced profit policy
- Delayed and reduced progress payments for work completed
- Three to four-year delays for auditing and payments on completed work
- Cost sharing on DoD-unique high-risk research

- Delays in awarding contracts
- Delays due to new protest procedures
- Abuse of suspension and debarment procedures
- Fixed-price contracts on high-risk development
- Increases in disallowances for costs incurred on Government contracts
- Abuses of industrial proprietary data rights
- Awarding competitive contracts to the lowest bidder instead of the provider of the best value.

Some firms were forced to make large zero-profit bids. Others were forced to invest heavily in competitive programs when there was a considerable chance of not only losing the competition but having the program cancelled. [Ref. 38]

Researchers noted that the defense industry has a negative image. There are many in Government, the press, and the public who are suspicious of the defense sector. Occasional actions by the defense industry, in which it appears to take advantage of the Government add to this suspicion. However, the root of this problem rests with the Government's procurement process. [Ref. 39]

1. Prime Contractors

Each major prime contractor's annual sales to DoD exceed a billion dollars, and cumulatively capture around 50 percent of DoD's procurement dollars each year. There are two types of prime contractors. First, there are those whose work is almost exclusively in the defense industry and are highly sensitive to the cyclical defense budgets. Second, there are those which are commercially-oriented. The commercially-oriented firms have divisions that focus on work for the Government. In commercially-oriented firms, there is little integration of defense and civilian operations. For either type of firm, the result is a largely specialized industrial sector dependent on the Government for business.

The defense industry is relatively concentrated. The top 100 firms do about 75 percent of the business. This ratio has been consistent since the late 1950's. Most of the defense firms tend to specialize. For example, they would not only concentrate on missiles, but in very specific types of missiles, such as air-to-air or anti-aircraft missiles. This specialization, combined with the fact that DoD buys a weapon system of a certain type only once every 10 or 15 years, and usually award the contract to only one contractor, results in higher concentration ratios for selected weapon areas than are found in typical commercial sectors.

Among the few firms that are in any sector of the defense industry, there is fierce competition for new awards. A distinguishing characteristic of the defense business is the barriers to entry and exit. The barriers to entry include the following:

- A unique environment
- High capital investments in highly specialized equipment
- Long-standing relationships with the military services
- The need for high levels of engineering and scientific capability due to the R&D emphasis in initial contract awards
- The need for large cash reserves
- Specialized reporting requirements
- The required knowledge of detailed federal regulations
- Security clearances
- Political support

To produce complex, high-quality, low-cost systems requires very modern automated manufacturing equipment. The problem is that there are inadequate incentives to encourage defense firms to make the long-term capital investments necessary to drive down costs and improve quality. In fact, significant factors that discourage such long-term investments are built into the DoD's way of doing business. Numerous studies

have found that defense contractors invest in new manufacturing equipment and technologies at only about half the rate of comparable commercial firms. In 1977 and 1987, DoD tried to get defense contractors to increase their capital investment. DoD shifted to a new profit policy that allowed higher profits for those firms that made greater capital investments. A follow-up study by the Air Force in 1982 found that while profits had increased significantly, relative investment did not change. The average profit for the defense industry is about half that achieved by companies not heavily reliant upon DoD, around one-third that of exclusively commercial firms, and about 25 percent less than that of durable goods manufacturers.

In 1985, U.S. firms spent \$180 billion for mergers and acquisitions, versus \$120 billion on R&D and \$50 billion on net capital investment. Mergers in the defense industry can have a particularly damaging effect, since defense firms traditionally treat each of their plants as an entity with its own engineering, marketing, and management staffs. For example, when McDonnell Aircraft acquired Douglas Aircraft the two plants continued to operate separately without real consolidation. Thus, a firm was eliminated, but not a plant. Economists refer to such mergers, which reduce competition without reducing costs, as *unrationalized mergers*.

An increasing trend is the teaming of defense contractors to bid on the few available contracts for weapon systems. Prime contractors are often encouraged by the Government to team up so that they will be able to share the high-investment risk as well as to keep a large number of them in the business. In these teaming arrangements, several prime contractors become subcontractors to one another on various parts of a weapon system. Competition and innovation suffer. [Ref. 40]

2. Subcontractors and Part Suppliers

The differences between the prime contractor and the subcontractor/lower-tier supplier levels are not simply matters of degree. The two levels are quite different in many respects, such as the way in which business is done, the basic industrial structures, and the problems at the technical level. Legislation, regulations, policies, and procedures

are primarily written for prime contractors. Prime contractors pass many of these requirements down to their subcontractors. This amplifies the existing problems and differences.

A typical defense prime contractor subcontracts between 40 and 60 percent of a weapon system's work. Even though, small firms have made many of the breakthroughs in military technology, DoD has historically ignored the lower levels of the defense industry by assuming that the prime contractors would ensure their continued viability. Research indicates that prime contractors do not show much concern about the viability of lower-tier suppliers and subcontractors. The result is a deterioration of that portion of the defense industry, both in terms of numbers and of a growing dependency on foreign producers.

Warnings of the growing problems in the lower tiers of the defense industry were heard at the end of the 1970's, but not until the late 1980's did Congress, DoD, and prime contractors begin to gather data on these problems and to take corrective actions. Many of these suppliers are operating at or near full capacity and have substantial backlogs. Thus, an increase in demand during a production surge results in bottlenecks at these critical suppliers. These bottlenecks can substantially increase delivery times whenever there is any significant increase in demand. The following is a list of items that contributed to the decline of this portion of the defense industry:

- The Government often adjusts the prime contractor's contract according to the program's risk, but the subcontractor receives more difficult terms and conditions. One study found that in more than 85 percent of the cases where the prime contractor had a cost-plus-fee contract, the subcontractor had a firm fixed-price contract even though the subcontractor had the higher technical risk.
- Prime contractors are reluctant to flow down favorable contract clauses to their suppliers and subcontractors, and the Government does not require them to do so.
- The Government often makes capital equipment, manufacturing technology, and facility investments at the prime contractor level and makes few such investments at the lower tiers.

- Prime contractors are given legal rights and remedies against the Government which the subcontractors do not have against the prime contractors.
- The prime contractor is often assured of continuing as the sole producer of a product, but a subcontractor often has no such assurance.
- Prime contractors can often leverage the subcontractors by playing an opportunity of one program against another, but this is usually not done to the prime contractor.
- A prime contractor often imposes more stringent specification interpretations on a supplier than on its own internal operations, in order to have a buffer when supplying the final product to the Government.
- Prime contractors have experienced staffs to handle all of the Government paperwork. The lower-tier firms have more difficulty handling the defense procurement process.

Thus, many firms have been exiting the lower tiers, while commercially-oriented firms have not been entering. In addition, research indicates that firms are discouraged by the many barriers to entry, such as the significant marketing differences, the specialized tooling and test equipment required, the extensive reporting requirements, the inelastic demand, and the heavy concentration on engineering and scientific capability. Thus, only a few suppliers remain in the lower tiers of the defense industry, and they are highly specialized. The specialization of these firms in defense subcontracting means that the DoD loses the economies of scale that could be realized by combining defense and non-defense production in the lower tiers of the industry. [Ref. 41]

D. TECHNOLOGY AND NATIONAL SECURITY

Traditionally, DoD has defined a foreign source in terms of where the production facilities were located. Some analysts have suggested that DoD's definition be expanded to include both the location of R&D activities and foreign ownership and control. Therefore, a foreign source could be a possessor of a technology. The technology could be located in a foreign country or in the control of a foreign-owned business in the United States. [Ref. 42]

U.S. national security demands that its military forces have guaranteed, cost-effective access to the world's best technology. The traditional approach for the U.S. Government to meet defense technology requirements would be to use the DoD budget to conduct R&D, then procure from specialized suppliers, and from this build necessary production capabilities. In the past, when DoD requirements constituted a significant portion of the high technology market, this approach was successful. DoD demand was sufficient to sustain the technology and production bases at the leading edge. This had the potential of higher costs compared to purchasing commercial products. Today, with declining DoD budgets and reduced demand, this approach is both unaffordable and ineffective.

Such a specialized approach is unaffordable, because it does not take advantage of the economies of scale that come from high volume commercial production. Furthermore, it is ineffective, because it is unlikely that a defense-unique industry could keep pace with the rapid technological innovation driven by a highly-dynamic commercial sector.

DoD is entering a new era in which it will increasingly rely on commercial components and technologies to meet defense requirements. To maintain the technological superiority of the armed forces, commercial industry must be able to supply products using advanced technologies, at competitive, affordable prices. Thus, a new focus for DoD R&D must be to ensure that the key elements of the domestic commercial technology base remain at the leading edge to ensure U.S. national security.

The Government has developed a new technology strategy that will handle these major changes affecting national and economic security in the 1990's. That strategy includes the dual-use technology vision outlined by Secretary Perry. At the heart of this vision are two key principles.

- To reduce costs, and accelerate the introduction of new technologies into defense systems, DoD must make use of components, technologies and subsystems developed by commercial industry, wherever possible, and develop defense unique products only where necessary.

- To capitalize on this acquisition strategy, DoD's R&D efforts must focus on dual-use technologies and capabilities. [Ref. 43]

1. Implementing a Dual-Use Initiative

Any initiative under the dual-use strategy, rather than maintaining defense-unique producers, seeks to promote the creation of a viable domestic industry that is competitive in global markets, and is able to meet defense requirements by drawing on the commercial technology base. This strategy may call for initial investments, but these investments will mean substantially lower future DoD outlays as the services acquire lower-cost products from commercial suppliers, and rely on a healthy, domestic commercial industry to conduct future R&D investments into advanced technologies. According to DoD, to be successful new initiatives must be guided by six principles.

- The initiatives must be of sufficient scope and duration to attract significant industry participation.
- Industry must be willing to share in the costs of the initiatives.
- The initiatives should be based on principles of competition among firms and technologies.
- Given the international nature of modern, high-technology industries and the emphasis on achieving leading-edge capabilities, DoD programs should have the flexibility to consider participation by foreign-owned entities that satisfies program objectives.
- The initiatives should be consistent with other Government policy objectives.
- The initiatives must be subject to termination provisions and include clear success criteria for the continuing necessity of the initiatives over the near and long-term. [Ref. 44]

2. Defense Industry Conversion

In 1993, President Clinton proposed measures to lessen the impact of defense cutbacks by fostering programs to help contractors develop products for civilian markets. After the expenditure of several billion dollars of federal funds, defense industry conversion to commercial enterprises has not been as profitable as defense work. Many

defense contractors have tried to find nondefense projects, many with results below expectations. As an exception, environmental technologies have offered some defense contractors a promising market.

The National Commission for Economic Conversion and Disarmament (NCECD), a nonprofit organization in Washington, D.C., reports that defense-related jobs are increasingly disappearing. In the first half of 1994, 115,000 defense-related manufacturing jobs were lost. That is close to the total of 164,000 such jobs lost during 1993. The commission recorded the loss of 728,000 positions between 1990 and mid-1994. Secretary of Defense Perry warned that the defense industry base will shrink to a half or even a third of its mid-1980's size.

Instead of trying to contend with reduced defense budgets by converting to nondefense-related manufacturing, most companies have opted to either merge with or acquire part of a competitor. These new hybrid companies are then reduced in size. The recent emergence of the Lockheed Martin Corporation out of two former major defense contractors, Lockheed and Martin Marietta is a notable example. Each partner laid off about 8,000 workers during 1993, according to the NCECD. The NCECD predicts that approximately 15,000 additional Lockheed Martin workers will eventually lose their jobs.

Several U.S. defense contractors have tried to concentrate on Foreign Military Sales to contend with the declining U.S. business. The NCECD reported the share of American arms being sold in developing countries has increased from 10 percent in 1984 to 60 percent in 1994.

According to the NCECD, defense contractors have not, for the most part, developed commercial products, invested in retooling and marketing to become competitive in commercial areas, or retrained and redeployed their workforces. These companies traditionally existed to supply DoD with low-volume, specialty products. They now find themselves ill-suited to commercial markets, where keeping down costs is the primary concern. Small and medium-size companies with fewer than 500 employees seem to have the flexibility to make the changes needed to move into a new line of business.

Some defense contractors have tried to convert to the commercial marketplace. Hughes Aircraft, owned by General Motors, entered the television satellite business. Hughes, under the federal Technology Reinvestment Program, is now involved in projects totalling 75 million dollars. Few other companies have been as aggressive. The NCECD asserts that the Government has not provided "appropriate incentives and resources."

Environmental challenges have provided new business opportunities for some corporations that have traditionally relied on DoD. Westinghouse, for example, has moved into the business of cleaning up polluted sites. Raytheon won a contract from the Northern Illinois Regional Transportation System to investigate a low-pollution, rail-based, transportation system.

Some companies have refused to convert to the commercial market. McDonnell Douglas has been selling off its peripheral businesses in information systems and financial services. The company told its shareholders that it had no intention of diversifying into new businesses. Despite the generally poor showing to date, many other firms are still hopeful about prospects in civilian markets. Norman Augustine, head of Martin Marietta, predicts that 40 percent of Lockheed Martin's sales will be in civilian markets. The company should be able to capture 20 percent of the global satellite-launch market, according to another estimate. [Ref. 45]

3. Research and Development

With the end of the Cold War, national defense has become secondary to international competitiveness as the theme for federal support of R&D. Political support for federally-funded R&D is beginning to wane. Adjusted for inflation, the Government's R&D expenditures have fallen 7 percent since 1988. Spending on R&D in the private sector is still increasing, but its growth has fallen below the rate at which output is increasing. Investment in research is not keeping pace with the economy. These trends indicate a fundamental change in the rationale for federal research expenditures. From the beginning of World War II through the late 1980's, national security concerns dominated R&D policy. More than half of the federal R&D budget was devoted to defense technology, and much of the remainder supported those projects

with potential relevance to national security. The end of the Cold War weakened this justification for federal research. Figure 4 illustrates how privately financed R&D has become a larger percentage of the GDP compared to Government financed R&D. [Ref. 46]

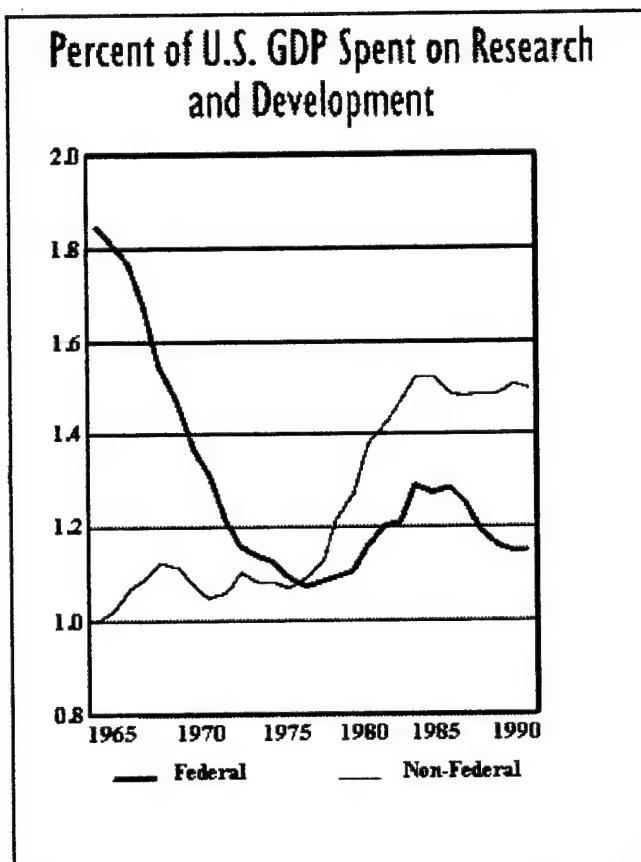


Figure 4. Federal and Non-Federal R&D as a Percentage of GDP, 1965 to 1990

During the past decade, the Government has sought new goals for its R&D investments. The most important emerging focus for Government programs has been to support R&D directed at increasing American industrial productivity and competitiveness. Some researchers assert that competitiveness is not politically powerful enough to replace the Cold War in forging a durable, bipartisan coalition to support R&D at the levels typical of past. In addition they claim, that the methods for implementing the new

programs are formed by political necessity and so are likely to undermine the economic performance of the programs.

Historically, a desire to help an industry increase productivity has played a role in R&D policy. The history of federal subsidies for commercially-relevant R&D exceeds 100 years. The Government supported the development of the telegraph and hybrid seeds in the 19th Century. Nevertheless, commercial programs did not become a significant component of federal R&D support until World War II. These programs were almost exclusively targeted at defense-related technologies. Various Government research programs for primarily civilian purposes did not begin until the 1960's. However, most federal R&D dollars were still spent on defense, or on basic research directly relevant to defense. In contrast, the current R&D approach is essentially economy-wide. Its appeal rests on the argument that it can help U.S. industry increase productivity and reclaim dominance in international markets. Almost any industry is a possible target for support.

The competitiveness theme has caused two major changes in how federal R&D programs are conceived and managed. One change is increased privatization of the selection and results of research projects. Privatization is evident when new Government programs give private industry both the decision-making responsibility in technical matters and essentially all of the intellectual property rights. The other change is increased collaboration among American firms and research organizations.

An example of these changes is in the open competitions held by the National Institutes of Standards and Technology for its Advanced Technology Program (ATP). Any firm or group of firms, in any industry, can submit a proposal for partial federal funding for a technology development project. Proposals are evaluated by criteria that include potential commercial success, a feasible commercialization and marketing strategy, technical interest, inability to obtain complete private backing for the project and the likelihood of broad applications. These projects do not have to relate to any specific Government objective.

Most of the funds for carrying out the new competitiveness strategy still go to programs that retain a Government focus. The Technology Reinvestment Program,

administered by the Advanced Research Projects Agency, has an annual budget of more than 500 million dollars. Its goal is to support projects that will allow firms to rely on commercial markets and profits while developing technologies useful for defense. In addition, several large industry-specific programs have been established, including Sematech (for semiconductor manufacturing technology).

Furthermore, the federally-funded national laboratories seek to conduct joint research with companies. These efforts are called Cooperative Research and Development Agreements (CRADA's). Like the ATP projects, CRADA's are available for all industries and need no connection to any Government program.

Despite Government contributions, these undertakings all part from traditional DoD R&D programs. Commercial technology development is a primary goal rather than an spin-off from carrying out a Government mission. Each venture relies on the private participants to propose and manage the projects. Each requires that property rights belong to the private participants rather than to the Government sponsor. All of the activities require private enterprises to share in the costs.

In theory, Government can solve the problem of underinvestment in R&D in two ways. The first is to promote the ability of innovators to obtain higher profits. In the past, the most important policy for increasing the profitability of innovation has been to strengthen intellectual property rights, such as patents, copyrights and protection of trade secrets. This approach has two significant disadvantages. First, it creates higher profits through the establishment of monopolies, which are inefficient. Second, any form of protection of intellectual property limits the circulation of the research results. Research often has applications in a variety of products and industries. The possible benefits of a discovery can be realized only if people other than the discoverers have the opportunity and incentive to apply those findings in new ways.

The other approach for solving the underinvestment problem is for the Government to pay for R&D through targeted programs. Under this approach, the Government selects specific technologies and projects. However, this approach has its drawbacks. If the goal of a program is to encourage commercial successes, the

Government is least likely to select the best projects. Furthermore, monitoring public research projects to assess private contractors' performance is difficult.

The monitoring problem is caused by the uncertainty about both the costs and the results of R&D projects. By the very nature of R&D, costs and results are not perfectly known. Consequently, the Government faces difficulties in specifying realistic technical approaches and objectives. Therefore, contracts are often based on a cost-reimbursement formula. Such contracts are known for their tendency to exceed projected costs.

The Government's traditional protection against companies that take advantage of cost and performance uncertainties is to impose demanding cost-accounting and auditing requirements on R&D contractors to try to find waste, fraud and mismanagement. This monitoring system applies to most of the new programs, and it is more complex, costly and inflexible than private sector monitoring systems. As a result, R&D done under Government contract is inherently more expensive and less effective than R&D done in the private sector. Government monitoring methods are so burdensome that many federal contractors separate their federal and private work so that they can use more flexible, inexpensive methods of managing their private R&D.

In the past, a political consensus for federal R&D was achieved by pursuing both approaches. Technologies in which private industry could hold a reasonably secure intellectual property right were expected to be backed by business. New knowledge resulting from Government-supported R&D was to be nonproprietary and widely disseminated. In addition, the Government encouraged defense companies to distribute their technical knowledge through subcontracting. It welcomed the commercial adoption of technologies that were not related to classified defense products. The new theme uses both approaches. [Ref. 47] Figure 5 illustrates the distribution between Government and industry R&D expenditures according to sector. The aircraft and missile sectors combine to receive the largest share of Government R&D funding. [Ref. 48]

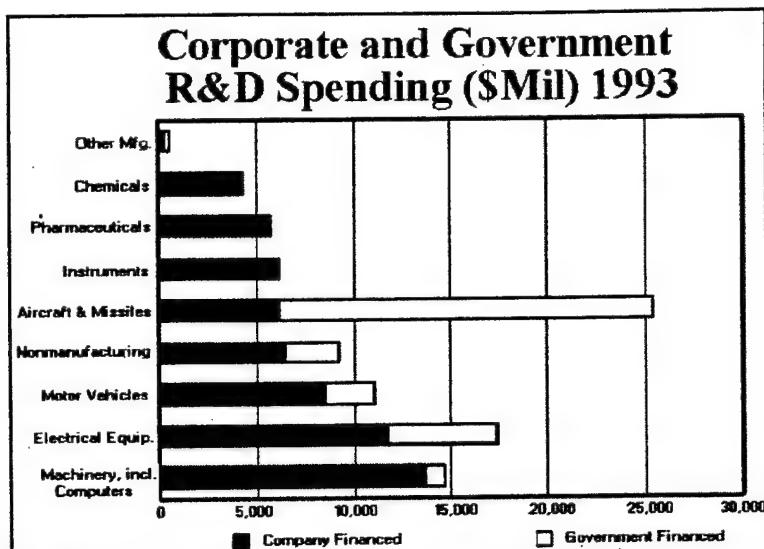


Figure 5. Corporate and Government R&D Expenditures by Industrial Sectors

An economic consequence of the privatization of knowledge is that it is more effective in encouraging the development of products than in generating scientific advances. A company usually cannot capture as much of the economic value of an advance in basic research as of an advance in a product or process.

Partly to encourage broadly-applicable R&D, the new Government programs propose that projects be undertaken by consortia or joint ventures of firms, perhaps together with universities and other research institutions. Initially, the ATP favored the formation of consortia that would conduct "generic, precompetitive" research, which the member companies could later apply to the development of competing products. Thus, the Government has tried to promote research activities that the private sector has traditionally neglected. In the past decade, the federal Government has also tried to stimulate joint research by relaxing some antitrust standards.

Research collaborations can be beneficial. If a firm is unlikely to invest in a research activity because it cannot capture the benefits, a joint venture may make the effort worthwhile. An example of this is research that expands the technological base of an industry, but allows each company to develop its own products and processes. In

addition, collaboration can enable each company to benefit from the external expertise available. However, collaborative research raises a dilemma. Although in theory, it can encourage research investments, it can also create cartels. Obtaining the maximum security for intellectual property rights requires the elimination of market competition, which necessitates that a cartel control the domestic industry and that barriers be erected against the import of the foreign products.

R&D collaboration among domestic competitors is not likely to have the undesirable effects of a domestic cartel in either of two cases. If world trade is free and several nations are efficient producers, a domestic cartel in an industry would only be another competitor in the global market. The collaboration might enable the domestic industry to achieve economies of scale in R&D. In addition, a collaboration is likely to be beneficial if its scope is limited to expanding the technological base of the domestic industry. Each firm in the industry can then use that technology to develop its own products.

The industry-wide centralization of applied R&D presents a country with an unpleasant choice. If the venture makes U.S. industry more productive than its foreign competitors, the domestic industry will retain most of the benefits of its expanded productivity by cartelizing the domestic market. If the venture fails to make U.S. industry more competitive, the domestic industry will lose market share to foreigners, leading to the imposition of import restrictions. Again, a domestic cartel emerges, but in this case, one that is inefficient as well as monopolistic. In either case, the main effect of centralized R&D is to transfer wealth to members of a domestic cartel and not promote the economic welfare of the country.

A possible alternative to centralized R&D is to support projects undertaken by only part of the domestic industry. That approach has been taken by the ATP, which supports separate competing proposals by different groups of firms that are pursuing advances aimed at the same products. This is the method proposed by DoD for the flat-panel display program. This strategy can be effective, because it can preserve competition while subsidizing proprietary research.

Such programs have run into obstacles. When a project becomes successful, outside firms perceive it as unfair on the grounds that the Government is interfering with the success or failure of companies in the industry. For example, Cray Research and two Government laboratories entered into a 52-million-dollar CRADA to develop supercomputing technology. It was cancelled after complaints from other supercomputer firms that the Government's subsidy gave Cray an unfair advantage. More often, such programs are not very successful.

Failures should be expected, because the results of an R&D effort are inherently unpredictable. Unfortunately, technical and economic failure may not result in the prompt end of a major project. Government officials, unlike businessmen, must be sensitive to the effects that cancelling a project will have on employment. Some planners have argued that requiring an industry to share in the costs of R&D would provide a motivation to discontinue funding for failing projects. That approach may work, except in the case of large projects which may become too politically important for the Government to abandon easily.

The U.S. has not yet found a politically-workable and economically-attractive means of encouraging technological progress. Both economic research on R&D and the historical experience with Government programs indicate that the most effective solution would be a combination of policies. [Ref. 49]

E. MULTINATIONAL ENTERPRISES

Multinational enterprises (MNE's) are critical to ensuring the health of the U.S. technology base. Today, the most technologically-sophisticated and economically-significant sectors of the U.S. economy are known for high levels of international production, foreign direct investment (FDI), trade among affiliated companies, and complex forms of international collaboration. The examination of MNE's is essential to the study of the problem, because of their influence on the foreign-dependency issue. MNE's are business organizations at the foundation of much of the U.S. economy. They are increasingly global in their outlook. According the Office of Technical Assessment

(OTA), foreign affiliates of MNE's control a substantial portion of the world economy, perhaps as much as one-fourth of all economic activity in their host countries. Intrafirm trade (IFT) may account for as much as 40 percent of all U.S. merchandise trade.

Many MNE's now deploy multiregional or even global marketing strategies. Some sell more abroad than they do at home. An increasing number of MNE's source a significant share of their parts through international channels, and many have located major production facilities in foreign countries. A growing number of firms from different nations enter into strategic alliances to pool financial and technological resources, and to gain access to foreign markets.

Compared to other advanced industrial nations, the U.S. exports five times more technology than it imports. Most of this trade is done within MNE's. Affiliates of foreign-based MNE's account for a substantial share of U.S. merchandise trade and the greatest portion of the U.S. merchandise trade deficit. Across the U.S., Europe, and Japan, affiliates of foreign-based MNE's tend to import more than do domestic firms.

International trade among affiliated firms tends to reflect the balance of investment between the U.S. and its trading partners. Between 1983 and 1992, IFT between the U.S. and Europe was roughly equivalent, accounting for 43 percent of all U.S.-European merchandise trade. Of that IFT, 43 percent was conducted by U.S.-based MNE's and 57 percent by European-based MNE's. IFT between the U.S. and Japan is far less balanced. Over the past ten years, IFT accounted for 71 percent of all U.S.-Japan merchandise trade. Of that, 92 percent was conducted by Japanese MNE's and only 8 percent by U.S.-based MNE's. These figures indicate that the majority of U.S. trade with Japan takes place within affiliated networks of Japanese firms.

Even though MNE's exert an increasingly significant influence on U.S. R&D, the Government currently is not able to monitor or fully evaluate the investments by foreign-based companies in the United States. An understanding of MNE's is necessary to estimate their value to the U.S. technology base and provide information to policymakers.

Large firms are an important source of national innovative capacity. However, they are increasingly multinational, deploying strategies based on global views. MNE's can move manufacturing plants, financial resources, and R&D activities on a global basis to respond to international business opportunities. While policymakers are concerned with the long-term health and capacity of the national technology base, MNE's are concerned primarily with the international competitiveness of their firm. The main challenge facing U.S. policymakers is to develop a national technology policy that encourages innovation within MNE's and directs the benefits of those activities to the U.S. technology base.

MNE's tend to concentrate R&D in the country of national origin. American-based MNE's conduct less than 13 percent of their manufacturing R&D abroad. Although no comparable data exists for European and Japanese MNE's, research implies that they conduct similar, if not smaller, percentages of their R&D overseas than do U.S. firms. However, foreign affiliates account for a small, but increasing, share of all R&D spending in the U.S. That share increased from 9.4 percent 1982 to 16.4 percent in 1992. Much of this growth, however, resulted from foreign acquisitions of U.S. firms in the late 1980's.

Trends in both R&D spending by MNE's and technology trade indicate that R&D generally remains based in distinct national technology bases. At the same time, MNE's are a principal mechanism behind the globalization of technology. Higher rates of external patenting, more rapid diffusion of technology across borders, increasing rates of overseas R&D activity, and the growing prevalence of international technical alliances support this assertion. However, OTA's analysis of these trends indicates that the degree of R&D internationalization is still relatively low.

Japanese firms acquire U.S. technology through different channels than European MNE's. Japanese firms buy an unusually large percentage of U.S. technology from unaffiliated firms. These transactions give a higher degree of control to the purchaser. Japanese firms generally keep a more control over the technology they purchase from the

U.S. than do European firms. In 1992, 43 percent of all U.S. technology sales to Japan were conducted between unaffiliated firms, compared to 11 percent for Europe.

The overall influence that MNE's have on the foreign-dependency issue cannot be overlooked. MNE's can affect U.S. industrial readiness in the short-term and technological superiority in the long-term. [Ref. 50]

IV. EVALUATING DEPENDENCIES

The GAO proposed a framework for evaluating the national security risks associated with using foreign sources for products and technologies. The first section of this chapter will describe the proposed GAO framework. The second section will describe the Analytic Science Corporation's risk assessment methodology. It uses both quantitative and qualitative measures for assessing the vulnerability related to foreign-source use. The third section reviews DoD's risk assessment policy (still being developed) for requiring the use of domestic sources. The Defense Systems Management College published guidance to assist the PM's in their evaluation of foreign-source dependencies. The fourth section will review this guidance and available Government remedies. The final section of this chapter will detail Moran's economic model for evaluating foreign-source dependencies. In addition, actions proposed by Moran will be reviewed.

A. RISK ASSESSMENTS

According to the GAO, the risks associated with buying defense goods from foreign sources depend on several factors related to, among other things, supplier location, political alliances, military function, and substitute availability. The risk determinants fall into two categories. The first category is the criticality of the items. The second category is the likelihood of loss of access. The category of likelihood of loss of access can further be divided into three areas: disruption of supply from foreign sources, availability of alternate supply sources, and adequacy of surge capabilities. Criticality and the three areas under likelihood of loss of access have several key risk factors that can be applied when evaluating foreign-source dependencies. Figure 6 details this methodology of assessing risks identified with foreign-sourcing.

Factors to be considered when evaluating the criticality of an item or technology are as follows:

- The importance of the item or technology

- Stockpiling potential
- Technical substitution possibilities
- Linkages to other goods, industries or technologies
- Degree of technological maturity

RISK DETERMINANTS			
CRITICALITY	LIKELIHOOD OF LOSS OF ACCESS		
	Disruption of Supply from Foreign Sources	Availability of Alternate Sources	Adequacy of Surge Capabilities
Importance of the item. Stockpiling potential. Technical substitution potential. Linkages to other goods. Technological maturity.	Distance from source. Location of facilities. Transportation exposure. Risk of natural disturbances. Political stability. Economic stability of country. Trade stability. Internal business environment. Economic stability of firm.	Supply concentration. Dual-use options. Scale effects on industry. Reconstitution potential.	Surge capability of existing sources. Availability of additional sources in a crisis.
TIME FRAME			
Short-Term	Middle-Term	Long-Term	

Figure 6. Risk Determinants Framework

When considering the importance of the item or technology, the impact of the loss of an item or technology to the overall defense mission as well as the performance of the weapon system should be considered. In considering stockpiling potential, the risk of obsolescence of the item must be included. Many items, such as semiconductors, become obsolete relatively quickly in the course of rapid technological change. Stockpiling an item that can be replaced by a newer generation product that may be easier and less costly

to produce may cause more problems than it solves. With the trend of using commercially-available products for military use, technical substitution possibilities and linkages to other goods, industries, or technologies may increase.

The second area is the disruption of supply from foreign sources. The factors to be considered when evaluating this area are as follows:

- Distance from source in shipping time
- Location of manufacturing or engineering facilities
- Transportation exposure
- Risks of natural disturbances
- Country's political stability, including ties to the U.S.
- Country's economic stability, such as debt and/or exchange rate
- Country's trade stability, such as dependence on other foreign sources
- Country's internal business environment, such as regulatory environment
- Foreign firms' economic stability

The distances from the foreign source in terms of required shipping time becomes an important factor in an emergency. One should assume that shipping times may increase in a crisis. The locations of engineering and manufacturing facilities are important factors, especially when they differ from the locations of assembly and packaging locations. The loss of access to engineering and manufacturing facilities would have a potentially greater impact on meeting surge requirements. Longer or vulnerable transportation routes require more security forces that may not be available in a crisis. When considering the stability of sources' host countries, their political, diplomatic, and economic relationships with the United States must be examined. With the loss of a global threat, other countries may not feel as obligated to support U.S. actions as in the past.

When evaluating the availability of alternate supply sources, the following key factors should be considered:

- Supply concentration
- Dual-use options or the availability of items from commercial suppliers
- Scale effects on U.S. industry from decreased purchases
- Potential to reconstitute a lost U.S. industry

Supply concentration increases U.S. vulnerability as fewer worldwide sources have the capability to control the production of goods and the distribution of technology. Dual-use options must be considered as the potential availability of the same or similar goods from commercial suppliers increase. For example, some commercially-available semiconductors could replace similar items produced specifically for military products. Scale effects can occur as purchases from domestic sources decrease, because of increased foreign-source use. A reduced number of domestic sources in peacetime may have a negative impact on America's ability to surge production, especially if foreign sources are lost. Lost U.S. industries may not be easily reconstituted if sophisticated capital equipment and skilled labor are not readily available.

There are two key factors to consider when evaluating the adequacy of surge capabilities:

- Ability to surge existing suppliers during a crisis
- Timely availability of additional suppliers during a crisis

Some research has cited that sufficient information of the capacities of foreign sources is not available. If a foreign source is operating at a level near its capacity, the source probably could not meet surge requirements in an emergency. Additional suppliers must be identified. As stated in a previous chapter, the Defense Production Act has provisions that enable alternate sources to be made available in an emergency.

Risk assessments depend on the timeframe being considered. The risks of using foreign sources differ, when viewed from the short versus the long-term perspectives. As the timeframe expands, uncertainty increases.

In the short-term (less than three years) foreign-sourcing could lead to a lack of critical items during a crisis. These critical items would most likely be expendable items, such as missiles and spare parts.

Beyond the short-term, the focus would be the country's ability to produce major end-items. Research has noted that in light of current threats the risks of major disruptions in the production of end-items are small. The main long-term risks associated with foreign-source dependencies are in the reliance on foreign technologies and failing to maintain technological superiority.

Screening criteria can be used to narrow the field of foreign-source dependencies. Studies have cited two types of possible screening criteria that can be used: criticality and concentration of sources.

In using criticality as a screening criteria, some researchers have noted that both the Commanders' in Chief Critical Items List and the Defense Key Technologies List can increase the objectivity of the screening process. However, others have argued that these lists are too broad in scope and limit detailed examination. The Critical Items List focuses on systems, subsystems and components. These items are assemblies of different elements and materials. Each element or material has its own characteristics, such as criticality, technologies, processes and sources. A detailed examination of these elements and materials cannot be accomplished with the data presently available to DoD.

Other researchers have noted that using concentration of sources as a screening criteria is quantifiable, straightforward, and resistant to artificial claims of vulnerability. Opposing arguments question whether markets for defense goods can be defined so that concentration measures are both meaningful and obtainable.

Data necessary to assess the risks associated with the use of foreign sources for critical items is not readily available. It can be quite costly to collect, maintain, and

analyze data on foreign sources. However, some experts contend that if foreign sources are screened effectively, data-related costs would not be prohibitive. [Ref. 51]

B. THE ANALYTIC SCIENCE CORPORATION'S RISK ASSESSMENT

The Analytic Science Corporation (TASC) developed a framework to assess the risks of buying defense items from foreign sources. TASC sought to develop a methodology for assessing vulnerability by identifying and testing objective measures that determine the extent of the threat to national security. From their measurements, TASC attempts to establish priorities for Government action by suggesting actions that could be taken to identify the scope and nature of foreign-dependence, and the actions that could be taken to avoid future foreign-dependencies.

TASC defines foreign-sourcing as "the purchase of goods, services, or technologies from sources outside the United States and Canada." In addition, TASC defines foreign-dependency as "a situation where goods and services are purchased from a foreign source of supply with no adequate alternate source or substitute within the U.S. or Canada." Foreign-vulnerability is defined as "a situation where a foreign dependency exists and national security could be threatened by a disruption in supply."

TASC proposes an initial screening process that begins with a qualitative analysis of an item's criticality to national security. Factors to be used as the basis of the assessment can be obtained from various DoD reports on critical items and technologies, such as:

- Its essentiality
- Its ability to be reconstituted once lost
- The ease which expertise can be defused
- The rate of technological change and R&D expenditures
- The linkages between industries
- The spillover effects of one technology's loss upon another

- An industry's structure that promotes entry barriers to alternate sources
- Geographic location
- Various types of reliability (including political and financial)
- The ability to stockpile and substitute items.

Once the screening process is completed, TASC's methodology calls for a quantitative assessment of vulnerability based on the Herfindahl-Hirschman Index (HHI), a measure of the number of firms and distribution of market shares among them in a well-defined market. The HHI is calculated by summing the squares of the market shares of individual firms in a particular market. For example, if there are ten companies, each with a ten percent market share, the result is a HHI of 1000. The HHI serves as indicator of the ability of foreign firms or nations to collude and deny the U.S. of critical items or technologies. A market with a HHI of 1000 or less is defined as secure. A HHI above 1,800 indicates that a market is vulnerable to collusive activity. For example, if there are five firms each with a 20 percent market share, the result is a HHI of 2000. It is easier for five firms to collude than ten. Results between 1,000 and 1,800, according to TASC, are inconclusive.

After assessing the vulnerability of a market, the next step in the TASC process is a static assessment based upon three different measures calculated using the HHI and different groupings of market share. The first measure is a geographical index calculated by grouping market shares by nation of origin. This index measures U.S. vulnerability to the denial of critical items by each foreign nation. Second, a foreign-dependence index is calculated by grouping shares of the U.S. market by nation, excluding the U.S. share of the domestic market. The foreign-dependence index measures the extent of U.S. dependence on foreign nations. Third, an entry-barrier index is calculated from international firms' (U.S. and foreign) world market shares. This index measures the extent to which production of an item is concentrated in a few firms worldwide. Finally, a measure of the rate and direction of changes of the HHI identifies trends that may lead

to a greater or lesser vulnerability in the future. In addition, changes in the shares of total industry R&D expenditures can be an indicator of future changes for product market share.

The TASC approach identifies Government actions for markets found to be vulnerable according to the results of the quantitative analysis. High-priority policy treatment is recommended if either of two conditions exist; (1) if the HHI is greater than 1,800 and the five-year change of the foreign share of the U.S. market is not negative, or (2) if the HHI is between 1,000 and 1,800 and the five-year change in the foreign share of the domestic market is greater than a 100 HHI. Second-priority treatment is appropriate in situations where; (1) if the HHI is between 1,000 and 1,800 and the five-year change in the foreign share of the U.S. market is between 0 and 100; or (2) if the HHI is greater than 1,800 and the five-year change in the foreign share of the U.S. market is negative. TASC suggests that low-priority treatment is appropriate if; (1) the HHI is between 1,000 and 1,800 and the five-year change in the foreign share of the U.S. market is less than 0, (2) or the HHI is less than 1,000.

TASC notes that the data required to do this analysis is available from industry surveys and other published sources. The HHI has been successfully used by the Departments of Justice and Commerce in conducting antitrust studies. Figure 7 illustrates TASC's risk assessment framework. [Ref. 52]

C. DEPARTMENT OF DEFENSE EVALUATION

The DoD Office of Acquisition and Industrial Base Policy is currently drafting a policy to guide Government officials in evaluating industrial and technological capabilities to determine if they are essential to the national defense and whether the Government should take action to assure their availability. The policy will also address the additional considerations to be used to determine the extraordinary circumstances under which a capability should be domestically-sourced. It is DoD policy to meet defense needs through reliance upon an industrial base sustained primarily by commercial demand, while it is capable of meeting DoD's requirements. DoD will rely on market forces to

The Analytic Science Corporation
Framework for Assessing Risk of Foreign Sourcing

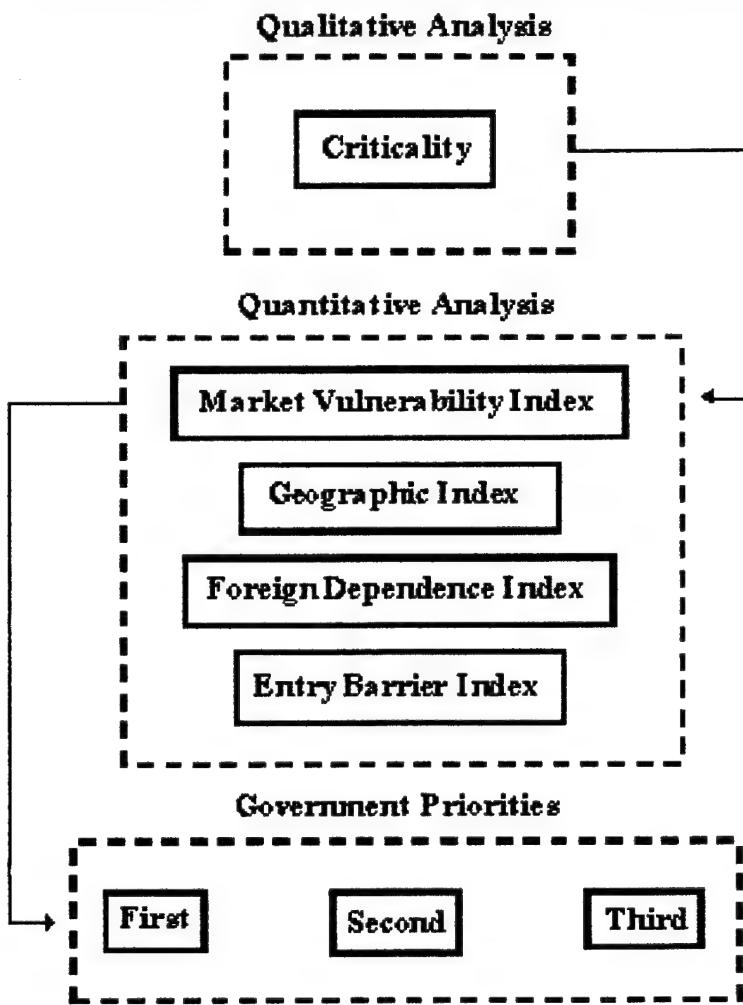


Figure 7. TASC Framework for Assessing Risk of Foreign-Sourcing

the maximum extent possible to guide the consolidation of the defense industrial base. Only in exceptional instances will DoD intervene to ensure the availability of industrial and technological capabilities necessary to support defense requirements.

A three-step process will be used by DoD to identify and evaluate those instances that merit Government intervention. First, DoD must identify those essential capabilities that require domestic sources. An essential capability is one that is necessary to meet

warfighting demand arising from the Defense Planning Guidance (DPG) document. The second step is the identification of endangered capabilities. An endangered capability is an essential capability that will most likely not be available to support defense peacetime requirements detailed in the Future Years Defense Program (FYDP) and emergency demand in the foreseeable future. In the third step, DoD must determine the appropriate Governmental intervention. The intervention determination step asks how and at what cost DoD and other agencies might intervene to address unacceptable risks.

1. Determining Whether a Capability is Essential

In determining whether a capability (skill, process or technology) is essential, DoD specifies four requirements that must be met. A capability is essential if it is:

- Necessary to support the military mission, and
- Necessary to meet readiness/sustainment requirements, or
- Necessary to maintain technological superiority, and
- Subject to regeneration limitations.

In supporting a military mission, the capability is needed to design, produce, repair, or maintain products required to supply and equip the force structure of the armed forces. The capability must be funded in the FYDP and required by the DPG to be funded in future FYDP's. It must also be required in the DPG to meet emergency/crisis demand, now and in the future.

Readiness/sustainment requirements call for a capability to be integral to a system, item, component, commodity, or part that has a limited shelf life, high stockpiling costs, or scarcity of supply due to limited capacity. A capability necessary to maintain technological superiority is subject to substitutability limitations when there are neither available nor potential substitutes, nor alternate sources. In addition, the loss of the current source, or sources, of the capability, domestic or foreign, would adversely impact military readiness. If regenerating a capability would take longer than the available warning time under the appropriate DoD scenarios, or involve significant and identifiable

risks that would be extremely difficult to overcome or require significant costs, that capability meets the regeneration limitations requirement.

2. Requiring a U.S. Source

The Government should consider requiring or developing a U.S. source for a capability only in the cases outlined below. Figure 8 illustrates this evaluation process.

- It is essential to national defense, and
- A U.S. source is necessary to ensure readiness/sustainment, or
- A U.S. source is necessary to ensure continued access to technology, or
- U.S. control is necessary to limit or deny access to capabilities.

The previously mentioned definition of an essential capability applies in this stage of the process. DoD requires a U.S. source to ensure readiness/sustainment, because there is no acceptable foreign source. A foreign source, according to DoD is unacceptable when a capability resides in, or can be limited by, a potential adversary, or it creates vulnerabilities caused by the concentration of sources in a foreign base, or it is militarily urgent that the U.S. can control emergency production and support through U.S. laws.

Continued access to technology is necessary when a capability is integral to advanced, militarily-important items, or military requirements cannot be met from foreign sources, or the absence of a U.S. source can cause technical risks. Technical risks are those that can harm defense-essential elements of the R&D, production, or support infrastructure.

U.S. control is necessary to limit, or deny access to capabilities which, if available to foreign countries, would endanger national security. Examples of these are highly-classified technologies, technologies with potential use in the production of weapons of mass destruction, and defense items using sensitive information that could result in the development of effective countermeasures. [Ref. 53]

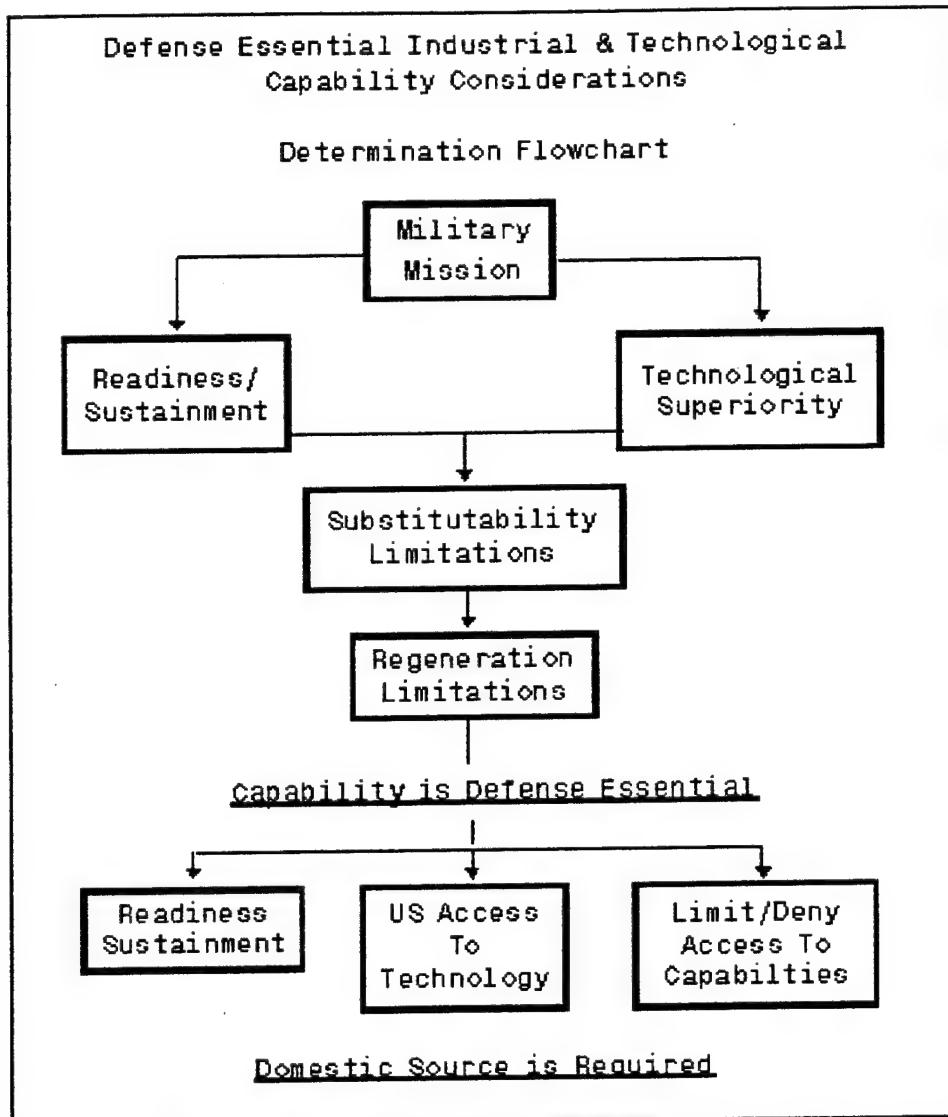


Figure 8. Defense-Essential Industrial and Technological Capability Considerations

D. PROGRAM MANAGEMENT EVALUATION

According to the Defense Systems Management College, three steps are required in the analytic process to address foreign-dependency issues:

- Determine whether foreign sources are used. During this step vulnerable materials and components are identified.
- Determine if any of the foreign-sourced items could prevent an end-item from

reaching its peacetime, surge and mobilization production goals.

- Determine if DoD guidance exists, or is necessary, and if any action is appropriate to reduce/eliminate the dependency.

Manufacturer-provided data is necessary to accomplish steps one and two. However, step three is the responsibility of the Government. During the third step, the PM should conduct a risk-versus-benefit analysis. The PM could determine if corrective measures were appropriate. Corrective actions could be either long or short-term in nature. An example of a long-term action is to begin a new R&D program. A one-year stockpile would be a short-term alternative. At the third step above, there are several possible solutions that should be considered.

1. Establish or Increase Visibility and Responsibility

Any data system used to collect information for managing foreign-source use should operate on a management-by-exception basis. The danger of not using a management-by-exception method is that the data requirements would become too great and cost-prohibitive. Most DoD information is currently developed by individual weapon system. Proper visibility would require information across all weapon systems for a particular critical component, for several weapon system producers could be dependent on the same supplier. Additional funds may be required by PM Offices to pay for the data and budgets should reflect the planned costs for finding this data.

2. Stockpile Vulnerable Components

There are several approaches to stockpiling critical components. Three approaches are: a rolling inventory, stockpiling for surge, a life-of-buy procurement. These approaches have been successfully implemented in the past. Their main disadvantage is cost. There is also the risk that stockpiled components may become obsolete. The cost of establishing a stockpile is a small percentage of the total life costs of a system and the risk of obsolescence is small. The early purchase of parts can pay for itself in the savings from avoiding inflation costs and realizing lower unit costs from the larger production amount.

A rolling inventory could be established. A PM could purchase one year's worth or more of a foreign-made critical component in advance. The initial buy would be considerably more expensive. If one year's worth of components is bought in addition to the first year's required components, the cost would be essentially double, except for discounts for the larger volume. However, after the initial buy, orders for additional components would operate normally, but one year in advance.

Stockpiling for surge is a viable option. With this approach, a PM would buy the required foreign-made components for surged production during peacetime, in addition to the normal peacetime quantities. This approach is essentially the same as a rolling inventory, but at larger levels of procurement.

A life-of-buy procurement could also be used. This approach is the purchase of enough components to complete planned production and logistical support needs of a weapon system. The total initial costs of the weapon system would be greater, but it minimizes the impact of the loss of a foreign source.

3. Plan for Substitution

With proper planning, substitute components could be used if the supply of critical components were interrupted for an extended period. The use of substitute components could result in a degradation in a weapon system's performance or life. At least three approaches to planning for substitution appear attractive:

- Use of nonmilitary specification components.
- Use of derated military specification items.
- Reverse-engineering of foreign-made components.

There are risks associated with using nonmilitary specification components, such as reduced survivability. A nonmilitary component may not be able to perform as required in a battlefield environment. The use of derated military specification items is an inefficient use of resources. A derated component was designed and produced for superior performance compared with the item it is replacing. The main disadvantage is

cost. An example of using a derated item is replacing a circuit board rated for voltages up to 120 volts with one rated for 240 volts. Reverse-engineering a component takes time and can be costly. Its performance may not equal that on the original component.

4. Redesign System to Eliminate Dependency

It is sometimes necessary to redesign a system, or a part of a system to eliminate a foreign-dependency. The cost of engineering redesign would add to the system's total cost. In addition, the resultant weapon system may have inferior performance and increased production costs.

5. Target DoD Investments

With this approach, the Government invests in R&D, or manufacturing areas where U.S. companies find it uneconomical to invest. An example of successful past Government investment is the DoD investment in Very High Speed Integrated Circuits. There was an inadequate commercial market for these components, but a significant military need. DoD invested in both the R&D and the manufacturing process. DoD limited itself to domestic bidders and created the potential for a U.S.-unique capability. It is possible that companies can develop markets for the products resulting from Government investments and compete economically. However, there may be a need for further Government investments if firms fail to compete economically.

6. Specify Procurement and/or Acquisition Policy Changes

There are no policies that dictate specific criteria to determine what is an acceptable level of foreign-source dependency. Below are five policies that could be considered in managing foreign-source dependency:

- A delivery commitment or contract for foreign-source components.
- A requirement for at least one U.S. source for critical components.
- A requirement placed on prime contractors to guarantee contractually component supply.
- A requirement that the Milestone III decision include an impact analysis and a contingency plan for foreign-sourced components.

- A shift to common buying for critical components to remove the decision from PM's.

Delivery commitments or contracts for foreign-source components would be effective in minimizing firm-initiated denial or delay of components. Penalties and price incentives could be useful measures to ensure timely deliveries of critical components. However, as shown in the historical examination of foreign-source dependencies, a national government-directed delay or denial of components to another nation's firms could take precedence over contractual obligations. Using a foreign source while maintaining a domestic source could produce the expected cost savings of using dual sources. In addition, with an active domestic source available vulnerabilities are reduced. Contractually obligating prime contractors to guarantee component supply would be effective if the PM knew which components were critical and which ones were being, or had the potential of being, foreign-sourced. Monetary rewards and penalties would be effective, because both measures have an impact on a firm's profits.

7. Support Foreign Direct Investment in the United States

Direct investment overseas has its advantages and disadvantages. Foreign direct investment by U.S. investors is the source of most of the foreign-source dependencies associated with electronic components and parts. Direct investment by foreign nationals into the U.S. has been responsible for easing an adverse situation. Examples of direct foreign investments in the U.S. include Japan's Kyocera facility in San Diego that produces ceramic packages, and both Germany's Schott and Japan's Hoya facilities that supply DoD's sophisticated optical glass. Government support of foreign direct investment is a low-cost alternative to reducing foreign-source dependencies. It is especially effective in areas where foreign firms possess superior technologies.

8. Use the Provisions of the Defense Production Act

a. Establish Standby and Voluntary Agreements

This would provide a low-cost method of preparing for the potential loss of overseas suppliers. Under the provisions of the Defense Production Act (DPA), there are five possible methods that can help reduce foreign-dependencies.

First, surge option clauses could be negotiated with alternate domestic producers. Second, the Government could negotiate standby agreements to obtain data rights from foreign sources in the event of a surge. Alternate domestic suppliers could voluntarily agree to return proprietary data after the production returns to normal, and they then leave the business area. Third, under voluntary agreements, foreign firms could provide technical assistance to domestic firms in case of surged production. Fourth, educational orders, a form of standby agreement, could be used to train, facilitate and qualify domestic sources. Fifth, voluntary agreements for domestic production of foreign dependent systems could assist new producers in achieving rapid production and resolve bottlenecks caused by the loss of foreign sources.

b. Expand Production Capacity Using Title III of the DPA

Although Title III can be a valuable tool for increasing domestic capacity to produce critical items for DoD, it should not be a total solution to the foreign-source dependency problem. To expedite or expand either the production of critical items, the development of critical technologies, or the procurement of industrial resources essential to the national defense, the Secretary of Defense is authorized to make direct loans, loan guarantees and purchase commitments from Title III appropriated funds. If DoD commits to the purchase of a specified quantity of an item, then incentives may be created for firms to make capital investments they would otherwise not make.

9. Purchase Design Rights

The purchase of design rights is a simple solution, but it is a limited one as well. Design rights clauses are standard in every Government contract, but they are negotiable.

By purchasing design rights, it is possible to reduce the amount of time required for an alternate source to begin production.

10. Invoke Exception 3 to the Competition in Contracting Act (CICA)

As mentioned earlier, the FAR allows exemptions to full and open competition. The basis for this exception is the CICA. Exception 3 of the CICA is for the maintenance of domestic sources for national mobilization or surge. This exception can be used in a variety of ways, including the following:

- Establishing split procurements
- Excluding foreign competition
- Directing procurement to a specified domestic source. [Ref. 54]

E. ECONOMIC EVALUATION

Research cites that foreign-source dependency is one of the three main, overlapping, yet distinct economic threats to American national security.

- The fundamental and cumulative economic decline,
- The loss of specific economic and technological capabilities, including competitiveness,
- The dependence on foreign suppliers.

Once it is understood that the threat of foreign-dependency is from the external concentration in key industries, economists can evaluate national security implications of a foreign-source dependency. Theodore Moran believes that national security analysts and economists can agree in this manner. The potential for foreign control decreases as the proliferation of suppliers increases. It is from the economic examination of the problem that a definition of what constitutes an "unacceptable" foreign-source dependency is derived.

A foreign-source dependency is unacceptable when the credible possibility exists that a foreign source, government or business, may delay or deny materials or components in order to influence, manipulate or blackmail the Government or U.S. businesses.

1. The Four-Four-50 Rule

A guideline that can be applied in determining whether or not a dependency is unacceptable is known as Moran's "Four-Four-50 Rule." It is based upon empirical findings from antitrust studies. If the largest four firms or four countries control over 50 percent of the market, they hold the potential to coordinate delay, deny, manipulate, or blackmail. The rule has proven itself useful in developing economic and antitrust policy.

Moran asserts that in order for the threat of a deliberate delay or denial of needed items by a foreign source to be credible global markets must be concentrated. The threat hidden in the globalization of the industrial base does not rise from the extent of the dependence, but from the concentration of dependence on a few foreign suppliers where substitute items are scarce, domestic production capability is not sufficiently available, and stockpiling is not feasible. [Ref. 55]

2. The Moran Model

The model that incorporates the Four-Four-50 Rule is illustrated in Figure 9. It lays the foundation for deciding which dependencies are unacceptable and require special attention. Security is defined in the model along two axes. The horizontal axis is the degree of foreign-dependence (foreign companies or foreign locations). The vertical axis is the degree of concentration.

The worst position is point X. An example of point X is France's experience in 1964 to 1966, mentioned earlier, when it was forced by the U.S. to cease its hydrogen bomb program. Moving along the concentration axis towards point A, there is an increasing degree of competition. At point A, security would not be threatened even if most or all the suppliers were foreign companies. Economists prefer this situation since they would argue that there would be a more efficient use of resources, more innovation

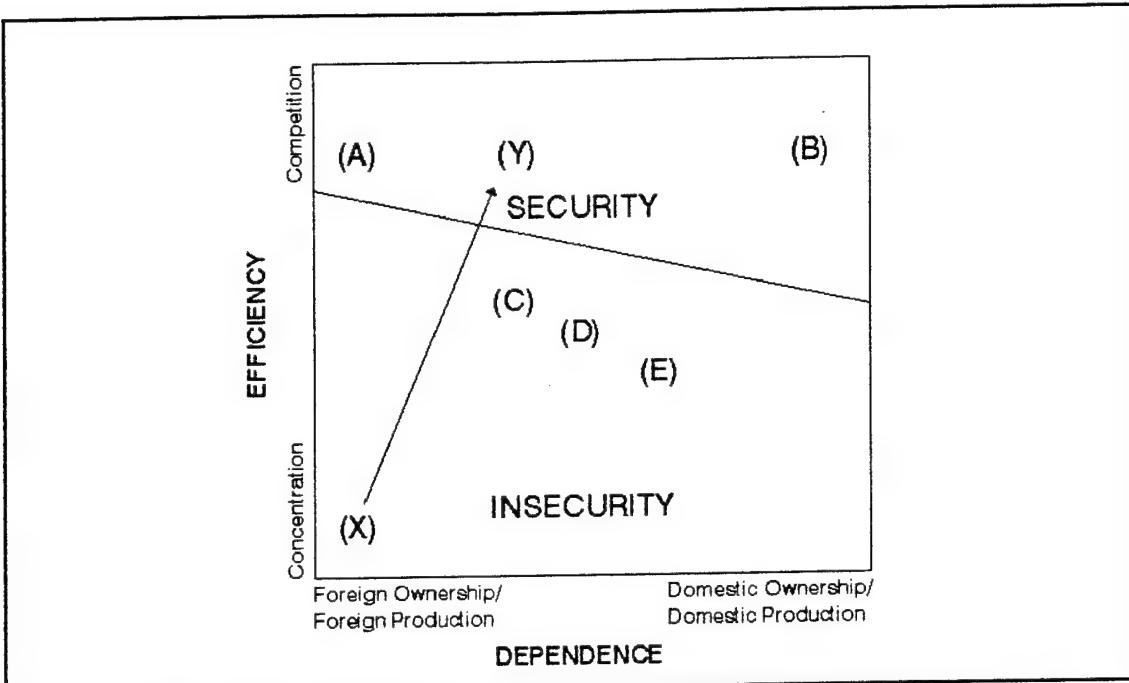


Figure 9. The Moran Model

within industries, and a condition close to world-class performance.

Point B lies at the foreign-dependence and concentration axes' extreme of no foreign dependence and highly-competitive industries. This is the ideal condition for concerns over foreign-source dependencies. When the nationality of firms or the location of production or technology use is mandated through laws or regulations, Moran believes that a country will end up along a path roughly parallel and below the line tolerable for security if it does not simultaneously result in a multiplication and diversification of suppliers. Point C is much like the condition experienced during the 1973 oil embargo, point D is like the Soviet gas pipeline example and point E is like the British AEW example. Moran states that toward the end the foreign-dependency axis, there is a broad region in which a country will almost achieve self-reliance, but in a condition of mediocrity adverse to national security.

The slope of the dividing line between security and insecurity in the model depends on the amount of influence exercised over suppliers by the domestic government. The Four-Four-50 Rule can empirically determine the slope of this dividing line. Moran

argues that the optimum approach would lead a country away from point X to point Y.

[Ref. 56]

3. Proposed Economic Policies for Addressing Risk

Moran incorporates his Four-Four-50 Rule into a proposed national strategy. His proposed strategy consists of three elements: promoting advanced industries, preserving threatened industries, and regulating foreign acquisitions of U.S. firms and foreign investments.

a. Promoting Advanced Industries

Moran contends that the first step toward achieving a goal of protecting the defense industrial base from foreign-dependence is the use of Government funds for innovation. Funds should be allocated according to the degree of usefulness to DoD. According to Moran, the first priority for funding should go to projects with high defense payoffs, but with little or no commercial value. The lowest priority should go to those projects with a dual-use potential. Once DoD has funded a project, foreign nations should be allowed to participate in the R&D of advanced technology programs. However, all R&D should be performed in the U.S. or a neutral third country.

b. Preserving Threatened Industries

Moran asserts that trade protectionism should be avoided. When it becomes necessary to impose trade restrictions, Moran recommends a tariff. This action is called for only when the concentration of industry meets the test of the Four-Four-50 Rule. In addition, quotas and voluntary restraint agreements should not be used, for they only cause inefficiencies in the marketplace. Voluntary restraint agreements encourage oligopolistic industrial structures. Moran opposes a set "strategic trade policy" to control foreign-dependence by restricting imports and promoting exports. Such a policy would provoke retaliation. The favored approach is what Moran refers to as a "push for parity" of access to national markets.

c. Regulating Foreign Acquisitions of U.S. Firms and Foreign Investments

Foreign acquisition of defense firms can represent a loss to the defense industrial base. Foreign direct investments can be considered a penetration of the base. Traditionally, the Government regulated foreign acquisitions and direct investment when classified materials were involved. Recently, the Government has moved toward restrictions by advocating industrial policies that try to minimize foreign direct investment. Moran asserts that these restrictions may no longer be appropriate, because of today's wider diffusion of advanced technologies. Moran outlines three instances when foreign acquisitions and direct investments may be warranted. The first instance is when foreign direct investments into the U.S. creates subsidiaries that try to increase production of defense-related products. The second instance is when a foreign buyer intends to divest himself/herself of all defense-related business. The third instance is when a foreign-purchaser of a U.S. firm has the clear intention to continue to operate a business of direct importance to the defense industrial base. The third instance should be screened using the Four-Four-50 Rule. [Ref. 57]

In the risk assessment process, the criticality and substitutability of an item and the foreign source's reliability, location and environment are key determinants of vulnerability. In addition, the domestic capability to produce a foreign-sourced item must be considered. The concentration of sources determines the extent to which foreign governments or companies can collude to deny, or delay deliveries. In the short-term, production lines are vulnerable as a result of foreign-source dependencies. In the long-term, the technological superiority of the United States' armed forces is jeopardized as a result of relying on foreign sources for critical items and technologies.

V. TRENDS IDENTIFIED IN LITERATURE AND SURVEY SUBSTANTIATION OF THOSE TRENDS

A. GENERAL

The data presented in this chapter will be used to explore the concepts discussed in previous chapters. The presented data is as current as possible, and it includes survey data and industrial base analyses from the Department of Commerce (DOC) and the Army Material Command (AMC) which were examined to assess the status of the missile industry. A survey performed by *Defense News* concerning the shrinkage of the subcontractor base was also reviewed and included.

Government and private investments in R&D, and their application to technologies considered by DoD as critical, will be reviewed to determine any favorable or unfavorable trends. Previous chapters noted that R&D is critical to the competitiveness of the industrial base and to the technological superiority of U.S. weapon systems.

The electronic components and equipment industries will be examined, especially the semiconductor industries. As noted later in this chapter, electronic components are estimated to make up about 60 percent of a weapon system's cost. As mentioned in previous chapters, semiconductors are often cited as an example of foreign-source dependencies in missile systems.

A categorization of products will be presented to enable further analysis of the items considered critical by DoD, as well as an analysis of the Industrial Preparedness Planning List. This chapter will show that the focus of critical item management is at the system, subsystem and assembly level and not at the lower element levels, such as semiconductors. For example, the lowest product level is raw materials, and have often been noted as a foreign-source vulnerability example. Significant changes that have recently occurred in DoD's assessment of the criticality of each of the many raw materials contained in the National Stockpile will be presented.

A survey was conducted of electronic component and semiconductor firms to confirm previously noted literature and studies. Thirty-three vendors responded to the

electronically-mailed survey. Seven Program Management Offices of U.S. Army missile systems were contacted and officials interviewed to substantiate the applicability of previously-cited research to Army missile systems.

B. THE DEFENSE INDUSTRIAL BASE

1. The Production Base Analysis

The Production Base Analysis (PBA), conducted by AMC, reviewed the status of the missile sector of the industrial base and created the Department of the Army Critical Items List (CIL). The CIL and the current or anticipated industrial base status for each item is in Appendix A. The PBA defines "critical" as "being absolutely necessary for the continued viability of the missile industry." The CIL consists of 24 technologies that DoD has determined as critical. Of the 24 critical technologies, 15 are considered as not being available, four as somewhat available and five as available. In addition, the manufacturing processes for the critical technologies are evaluated for their criticality and availability. Seventeen manufacturing processes are considered as critical, with seven determined as not available, five as somewhat available and five as available. All of the noncritical processes were available. Available is defined as possessing domestic capability. Somewhat available is defined as having access to a technology or process, but not possessing a totally domestic capability. Technologies or processes listed as not being available are either not adequately developed for production, not producible domestically, or not accessible by U.S. producers.

The purpose of the Army Data Collection Plan (DCP) is to collect data on the products of items in the CIL and their producers. The DCP is being used to develop the Industrial Preparedness Planning List (IPPL) which identifies items for which the industrial base will be protected. The Major Subordinate Commands of AMC added 175 missile-related products to the fiscal year 1994 IPPL for CIL items.

Except for two systems that went out of production in fiscal year 1994, production in the missile sector remains steady. According to the PBA, this is a positive indicator

that the industrial base probably could supply critical spare parts in an emergency, and maintain critical contractor expertise.

Of the 11 items in production, seven had Foreign Military Sales (FMS) programs in fiscal year 1993. FMS has served to keep production lines warm and prevent production gaps. For example, FMS is the only reason that the Patriot Missile, Launcher, and Radar Set production lines are presently operating.

Missile production in the U.S. is done predominantly by companies that are electronics manufacturers. Major subsystems are produced at the subcontractor level. The PBA described this situation as positive for two reasons. First, analysts have stated that defense electronics firms will suffer the fewest and smallest cuts of any area in defense procurement. Second, most of the major electronics contractors in the U.S. are all strong, well-managed companies that have extensive commercial business interests to keep those firms financially stable. A table describing the outlook of the missile industrial base in Appendix B. [Ref. 58]

2. Army Industrial Base Sector Surveys

In 1992, AMC asked five industrial base associations to survey 13 critical industrial base sectors. The purpose of the surveys was to determine the effects of the drawdown on these sectors. The large and small missile sectors were surveyed separately. A sector was considered strong if businesses were active with commercial demand. Acceptable sectors were stable, but were in need of some support. Weak sectors were experiencing declining business and were losing their ability to support a future emergency. Defense-dependent firms that produce military-unique items were included in the weak category.

The small and large missile sectors were categorized as acceptable. The survey determined that there are large segments of the sectors that are military-unique and/or totally dependent on defense business. The survey also noted that a shrinkage of the vendor base has occurred and that many contractors are leaving the defense business.

The survey projected that FMS and Strategic Defense Initiative Organization programs would be sustaining the missile sectors after many production lines cease

production for the U.S. armed forces. Off-the-shelf technologies were being considered for integration into existing weapon systems. [Ref. 59]

3. The Missile Industrial Sector

The DOC expected a real growth rate in shipments of U.S. missile systems and related equipment of nearly 2 percent in 1994. In addition, the DOC noted that defense cutbacks have reduced demand in the missile industry.

Overall, 1994 DoD missile outlays increased by 2 percent, followed by cuts of 2 percent and 3 percent in 1995 and 1996, respectively. The export market will become increasingly competitive as European and Russian manufacturers compete with U.S. companies for shrinking defense spending overseas. Sales of U.S. missile systems through FMS programs reached was an estimated \$338 million in 1993, down from \$599 million in 1992. Table IV lists the guided missile and parts exports and imports from 1990 to 1994 as published by the DOC. [Ref. 60]

	1990	1991	1992	1993	1994
Exports	1,306	1,204	1,428	1,200	1,210
Imports	83	106	108	103	96

Table IV. Value of U.S. Total Exports and Imports Guided Missiles and Parts, 1990-94 (in millions of dollars).

4. Survey of Plant Capacity Utilization Rates

The Bureau of the Census conducts an Annual Survey of Manufactures (ASM) that samples approximately 63,600 establishments selected from the 1987 Census of Manufacturers of over 348,000 plants and supplemented by samples of new manufacturing plants that have begun operations since 1987. The defined capacity levels are full production capacity and national emergency production. The full production capacity utilization rate is the percentage of capacity that could be utilized under normal operating conditions. The national emergency capacity utilization rate is the percentage

of capacity that could be utilized and sustained for one year or more under national emergency conditions. Table V following table shows the estimated production utilization rates and standard errors of the estimates for some of the industries of concern to Army missile system acquisition managers. [Ref. 61]

Industry	Full Production Rate	Std. Error	National Emergency Rate	Std. Error
All Manufacturing	76	1	60	1
Durable goods Industries	74	1	56	1
Advanced processing Industries	76	1	58	1
Electronic components and accessories	77	3	66	4
Electron tubes	87	4	63	7
Printed circuit boards	86	4	70	10
Semiconductors and related devices	77	4	73	5
Guided missiles, space vehicles, parts	61	3	45	5

Table V. Production Capacity Utilization Rates, Fourth Quarter, 1992

5. Shrinking Subcontractor Base

A 1994 *Defense News* survey shows that U.S. firms are reducing the number of subcontractors they rely on and are performing work previously done by subcontractors. Management of 67 percent of the firms that participated in the *Defense News* Top 100 survey indicated that they are trying to reduce the number of subcontractors they use. When prime contractors were asked whether they were subcontracting out more work, 47 percent responded that they were subcontracting out more work, 42 percent were

doing more work in-house, and 11 percent had not changed their strategy. Fifty-six percent of the firms responded affirmatively when asked if they are finding key subcontractors are leaving the defense business.

In the late 1980's, prime defense contractors began limiting the number of subcontractors they use. Recently, this trend has been accelerating. Some researchers contend that prime contractors are focusing on the best value from a small number of experienced firms instead of a large number of bids from many potential subcontractors. However, another influencing factor is the declining defense budget. With smaller revenues, prime contractors are trying to maintain their workforces by doing work previously contracted to smaller firms. [Ref. 62]

C. RESEARCH, DEVELOPMENT AND PROCUREMENT

1. Government R&D

The 1995 R&D budget for DoD increased less than one percent from 1994. According to the Defense Budget Project, a nonprofit research and analysis organization, the Administration's commitment to R&D funding is not clear. It plans to reduce R&D funding by about an additional 25 percent by fiscal year 1999, a time of rapid technological change. This would bring annual R&D funding to a level below the \$31 billion average of the past 40 years, and well below the \$42 billion average of the past decade.

The Administration's proposed fiscal year 1995 defense budget includes \$3.25 billion for the Ballistic Missile Defense Organization (BMDO), up \$513 million from the level provided for these programs in fiscal year 1994. In its fiscal year 1994 budget submission, the Administration decided to reorient the ballistic missile defense effort toward the development and deployment of theater ballistic missile defense systems. The Administration also announced that fiscal year 1995 through fiscal year 1999 funding for BMDO would total \$17 billion, \$1.1 billion less than projected in 1993. The breakdown of 1994 and 1995 ballistic missile defense R&D budgets is listed in Table VI.

Budget Category	1994	1995
Ballistic Missile Defense Organization	\$2.74	\$3.25
Theater Ballistic Missile Defense R&D	\$1.5	\$1.8
Other Ballistic Missile Defense R&D	\$1.1	\$1.2

Table VI. 1994 and 1995 Ballistic Missile Defense R&D Budgets

On the defensive side of missile procurement, high priority will be given to ground-based Anti-Tactical Ballistic Missiles (ATBM) and theater missile defensive systems over space-based interceptors. Funding for the Theater High-Altitude Area Defense Missile (THAAD) and the Patriot/ERINT programs will receive priority under the new plan. The Brilliant Pebbles program was reduced from \$219 million in 1993 to \$73 million in 1994, mainly for R&D. DoD requested \$484 million for the THAAD system, built by Lockheed, which will use a kinetic-kill missile with a range of more than 100 miles. Concern over fielding effective ATBM systems has increased as North Korea and China are believed to have stepped up sales of their respective Scud-C and M-11 missiles to Iran and Pakistan. Table VII compares the growth or decline of the procurement, R&D and overall national defense budgets from fiscal years 1980 to 1995.

	FY80 to FY85	FY80 to FY94	FY85 to FY90	FY85 to FY94	FY90 to FY94	FY94 to FY95
Procurement	116%	-26%	-29%	-66%	-51%	-5%
R&D	83%	51%	-2%	-17%	-15%	1%
National Defense	55%	3%	-13%	-34%	-24%	-1%

Table VII. Procurement, R&D and National Defense Budget Trends, FY1980- FY1995

In another area, the Army is seeking to develop deep-strike missile systems to engage enemy targets quickly and improve reaction times. The Army Tactical Missile System (ATACMS) is a ground-based, deep-strike system that would complement Air Force attack capabilities. DoD requested \$144 million in the 1994 budget to procure 255 ATACM's, and provided R&D funding to develop a longer-range variate.

2. Government Procurement

The 1995 Army procurement budget was reduced by 14 percent from 1994. The total DoD procurement budget has been reduced by 67 percent from 1985 to 1995. According to the Administration's plan, funding for procurement would begin to increase modestly within a few years and would exceed \$50 billion (fiscal year 1995 dollars) by fiscal year 1999. According to the Defense Budget Project, the consistent trend toward higher procurement costs in the past suggests that it may be too optimistic to assume that an annual procurement budget as low as \$50 billion will be sufficient over the long-term.

Table VIII illustrates the Army's procurement budgets by sector and their real growths of total obligational authority (in millions of current year dollars) for fiscal years 1993 through 1995. In addition, the DoD's Title III procurement budgets and real growth are included. [Ref. 63]

	FY 1993	FY 1994	FY 1995
Army Procurement	\$7,354	\$6,885	\$6,090
Real Growth		-9%	-14%
Missiles	\$1,001	\$1,046	\$594
Real Growth		2%	-45%
DoD DPA Title III	0	200	0
Real Growth		NA	-100%

Table VIII. Procurement Budget Growth/Decline, FY1993-FY1995

3. Commercial R&D Toward Critical Technologies

In 1990 and 1991, Congress enacted legislation designed to promote IR&D/B&P activities that strengthen the industrial base, enhance U.S. competitiveness, promote critical technologies, support dual-use technologies, and address environmental research. In turn, DoD modified its regulations accordingly.

In 1990, the General Accounting Office (GAO) conducted a survey of 121 defense contractors' Independent Research and Development (IR&D) and Bid and Proposal (B&P) costs. The GAO's objective was to determine to what extent were IR&D/B&P efforts being applied to technologies identified by DoD as critical.

The GAO determined that DoD did not collect data on contractors' IR&D/B&P expenditures that address technologies considered critical for long-term U.S. technological superiority. In 1990, the 121 defense contractors spent a total of \$7.3 billion on IR&D/B&P costs. Of the 121 contractors surveyed, 92 reported that they spent a total of \$2.9 billion of their IR&D/B&P expenditures on the goals listed in the DoD Critical Technologies Plan. The firms reported that most of the efforts were on near-term developmental projects aimed at designing, developing or testing a new or improved product. Sixty percent of the respondents expressed the opinion that legislation designed to encourage IR&D/B&P toward critical technologies had little or no effect on the work being performed related to dual-use technologies.

Applied and basic research comprised 26.6 and 4.3 percent of the firms' IR&D/B&P expenditures, respectively. Basic and applied research are longer-term efforts aimed at increasing scientific knowledge and exploiting discoveries. These projects tend to have higher associated risks and require more time to realize a return on investment. Near-term development made up 69.1 percent of IR&D/B&P expenditures. The GAO cited DoD officials who noted that the defense contractors' preference for near-term development is understandable, because the basic aims of companies is to invest in projects that provide a quicker returns on investment. [Ref. 64]

D. CATEGORIZATION OF PRODUCTS

For this thesis, a weapon system, such as the Patriot Missile System, is an integration of two or more other systems (i.e., launcher, radar, fire control, missile). There is no standard number of product levels. Various studies have used from three to fourteen levels. For examination of foreign-dependencies in this and following chapters of this thesis, a DSMC method of six levels of products will be used as shown in Figure 10. [Ref. 65]

Level one products are systems and end-items. Examples of level one products are missiles, launchers and radars. Level two consists of subsystems that are subassemblies of end items or major subdivisions of systems. Examples of level two products are a missile's guidance, rocket motor, and warhead sections. Level three products are components that are fundamental parts of subsystems and/or systems. Components are elements joined together to perform a specific function and normally can be disassembled. An example of a component is the safe and arm mechanism in a missile's fuzing section. Level four products are elements that are basic parts of components and/or subsystems. An element is one or more pieces joined together and normally are not able to be disassembled without destruction of the product. Examples of elements are IC's that are part of a missile's electronic components. Level five products are materials that are the basic ingredients from which an element is produced. Examples of this level of products are silicon wafers that are used to produce IC's. Level six consists of the raw materials that are usually mined or transformed to produce materials. An example of a raw material is a metal alloy used to produce a product. Of the 175 items listed in the IPPL, 169 items are at the levels where the key activity is assembly, levels one through three. Five items are elements and one is at the material level. There are no raw materials listed in the IPPL [Ref. 66].

PRODUCT LEVEL	NAME OF PRODUCT AND PRODUCT DEFINITION	PRODUCT EXAMPLES	KEY ACTIVITY AT EACH LEVEL.
I	SYSTEM The end product	ship, aircraft, tank, missile	<i>Assembling system</i>
II	SUBSYSTEM A subassembly of the end product; a major subdivision of the end product	engine, bilge, air conditioning unit, gun, avionics	<i>Assembling subsystem</i>
III	COMPONENT A fundamental constituent of a subsystem or an end product; a number of elements joined together to perform a specific function and capable of disassembly	carburetor, pump, heat exchanger, audio-frequency amplifier	<i>Assembling component</i>
IV	ELEMENT A fundamental constituent of a component or a subsystem; one piece, or a number of pieces joined together which are not normally subject to disassembly without destruction	screw, gear, rotor, frontwheel bearing, frame	<i>Making element</i>
V	MATERIAL The basic ingredient (material) from which an element is produced	fuel oil, plate, wire, casting	<i>Refining and/or forming material</i>
VI	RAW MATERIAL The mined (or untransformed) material	ore mineral, oil extracted	<i>Extracting raw material</i>

Figure 10. Levels of Products.

E. ELECTRONIC COMPONENTS AND EQUIPMENT

The Institute for Defense Analysis (IDA) studied the dependence of U.S. systems on foreign technologies, and concluded that the most significant concentrations of foreign technology sourcing were in microelectronics, certain types of production equipment, and advanced and specialty materials. They further noted that foreign-sourcing of technology exhibited an increasing trend in microelectronics, machine tools, lithography equipment and high-resolution systems. IDA studied electronic components, because of their importance to weapon systems. It is estimated that electronic components make up about 60 percent of a weapon system's cost. In addition, IDA cited the criticality of semiconductor manufacturing equipment. According to IDA, there is no imminent vulnerability from foreign denial or delay of technology under the present procurement

conditions. A heavy dependence existed on a few highly-concentrated foreign sources in certain mature technologies. [Ref. 67]

According to the DOC, the electrical components industry was the second fastest-growing industry in 1994. Shipments by the electronic components industry increased about 11 percent, in current dollars, in 1993, and 9 percent in 1994. American sales of semiconductor manufacturing equipment (SME) increased 18 percent to about \$6 billion in 1993, and increased an estimated 25 percent in 1994. However, DOC predicts that most of the weakest-performing industries in the near future are expected to be in aerospace and defense-related electronics.

Worldwide competition in the electronics components industry is fierce. The U.S. faces strong competition from Japan and other countries in technologically-sophisticated products. U.S. firms will frequently be the first to introduce new products, but the Japanese often refine the manufacturing process and produce large quantities at relatively low prices. In less sophisticated products, U.S. suppliers have difficulty competing with such countries as South Korea, Malaysia, and Taiwan, where production costs are low.

Despite the likelihood of increased business, 60 of the manufacturing sectors with expected growth cut employment in 1994. Electronic component firms were expected to reduce their workforces by nearly 2 percent. Many U.S. electronics companies have set up production and assembly facilities in Mexico to take advantage of their low wage rates. These companies receive electronic components from the U.S. and return the finished products. According to the DOC, the elimination of tariffs between the U.S. and Mexico, combined with simplified regulations affecting trade among Canada, Mexico, and the U.S. under the North American Free Trade Agreement, should stimulate further growth of two-way trade in the region.

Unlike foreign competitors, U.S. component suppliers do not have the advantage of long-term supplier relationships with manufacturers that purchase components and integrate them into electronic systems. Manufacturers in the U.S. tend to emphasize supplier flexibility, rather than lasting alliances. The DOC contends that in order for the

U.S. component industry to prosper in the face of global competition, better long-term supplier-manufacturer relations are needed.

The electronic component industry was expected to expand about 9 percent in 1994, led by the growth in the semiconductor sector, which is predicted to increase by 12 percent. The electronic components sector is forecast to grow at an annual rate of 6 to 8 percent through the late 1990's. Component suppliers will face a continuing demand for higher-performance products.

Within the next few years, new products will enter the U.S. market. These products will be based on developing technologies, including DoD-critical multi-chip modules and image processing. These products will require increased quantities of electronic components, both sophisticated semiconductors and advanced components. Many will use digital technologies where U.S. suppliers currently hold the lead. [Ref. 68]

1. Semiconductors and Related Devices

The U.S. semiconductor industry continued its recovery, because of renewed growth in major markets worldwide. Shipments by U.S. semiconductor firms rose an estimated 16 percent (in current dollars). U.S. companies experienced increased sales in every regional market, with the strongest growth occurring in North America and the Asian-Pacific region. [Ref. 69] In fact, recent trade studies show that the U.S. regained the lead in the world semiconductor market [Ref. 70].

Demand for memory chips is expected to show the strongest growth, followed by analog IC's and microcomponents. Competition will be intense, especially in application-specific integrated circuits (ASIC's) and microprocessors. The outlook for related devices and other active components is flat, except for cathode ray tubes, where demand should grow strongly as the production of video displays increase. Sales of specialized semiconductors for the defense sector are not expected to be higher, but the military will use increasing numbers of commercial-grade semiconductor products. [Ref. 71] Figure 11 illustrates the North American semiconductor market share by producing region [Ref. 72].

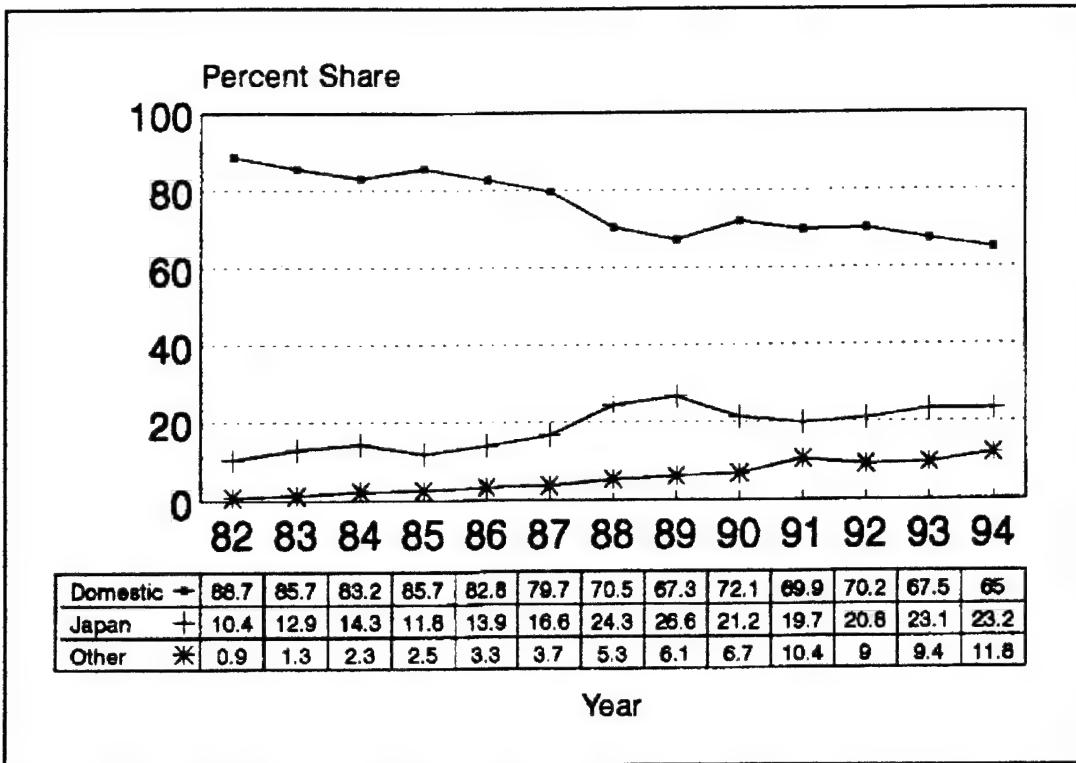


Figure 11. North American Semiconductor Market Share by Producing Region.

a. *Integrated Circuits*

IC's accounted for about 85 percent of all worldwide semiconductor sales in 1993, followed by single-function, discrete semiconductors, at 12 percent of sales, and optoelectronic semiconductors, at 4 percent. Memory IC's, microcomponents, and analog IC's are the categories expected to show the greatest increase in market size.

The microcomponent IC category includes microprocessors, microcontrollers, microperipherals, and digital signal processors. The fastest-growing microcomponent products in 1993 were microprocessors and digital signal processors with increased worldwide sales of 40 percent and 28 percent, respectively.

Some computer companies have entered into alliances with semiconductor makers to develop customized "systems-on-a-chip." Other chip makers use ASIC design and production methodology to incorporate standard microprocessors with other logic elements into custom chips. DoD-critical microcomponent ASIC's and system-on-chip

technology are expected to be among the fastest-growing segments in the microcomponent category in the 1990's. [Ref. 73]

b. Capital and R&D Spending

The U.S. semiconductor industry invests heavily in new capital equipment, facilities, and R&D for future growth. According to the Semiconductor Industry Association (SIA), from 1980 to 1992, U.S. companies spent an average 12 percent of annual revenue on R&D and 14 percent of annual revenue on capital equipment and facilities, well above the U.S. industrial average. [Ref. 74] Some recent research pointed out that U.S. chip-makers are in a stronger position today, because they invested heavily in R&D [Ref. 75].

Capital spending underwent a major adjustment from 1990 to 1992, to bring worldwide semiconductor production capacity in line with demand. Semiconductor manufacturers delayed or canceled new plants and closed older ones. This contributed to a capacity crunch that began to be felt in 1993. According to the market research firm, Dataquest, worldwide capital spending decreased in 1992 in all areas except the Asian-Pacific region.

The cost of a new semiconductor fabrication plant for high-volume production of dynamic random access memories increased from about \$400 million in 1990 to a range of \$600 million to \$1 billion in 1993. These costs are driven by the need for constant product innovation and advanced manufacturing technology. However, prices have remained relatively low resulting in insufficient profits to recover the R&D and capital expenditures required.

High capital costs have led semiconductor companies to adopt various capital-saving strategies. Some firms have resorted to smaller, specialized facilities. Many companies no longer can pursue technology-driven growth strategies. Instead, they seek to spread their costs by sharing manufacturing processes and equipment across their product mixes, and by partnering with other firms. [Ref. 76]

c. Strategic Alliances

Strategic alliances are survival tools for competitors in the global electronics market. According to Dataquest, semiconductor companies worldwide formed more than 130 strategic alliances during 1992. Corporate partnerships and strategic alliances allow companies to have access to new markets, technology, and manufacturing processes; increased financial leverage; stronger regional ties to smooth the effects of local economic downturns; wider product and technology commercialization; and opportunities to share growing R&D and production costs.

Strategic alliances among semiconductor companies include licensing and second-source agreements; sales agencies; fabrication, assembly, and testing agreements; technology exchanges; joint ventures; joint development agreements; and investment, standards coordination, and procurement agreements. Most U.S. semiconductor companies place high priority on alliances in their strategic plans. Alliances between U.S. companies were the most numerous in 1992, but there were significant numbers of U.S.-Japanese and U.S.-European alliances as well. Strategic alliances cover nearly all semiconductor products. The leading categories were memories, microcomponents, and DoD-critical ASIC's. [Ref. 77]

d. International Competitiveness

In 1992, North America surpassed Japan in total sales for the first time in several years, but the U.S. trade deficit in semiconductors was \$3.8 billion. The strong U.S. market was supported by semiconductor imports, which increased nearly 20 percent from 1992. In 1993, worldwide sales of North American semiconductors grew by 18.6 percent. Dataquest forecasts the North American semiconductor market to experience a compound annual growth rate of about 11 percent through 1997.

The dominant regional trading partner of the U.S. continues to be East Asia, which accounted for roughly half of U.S. semiconductor imports and exports in 1992. The strongest regional market growth in 1993 occurred in the nations of the

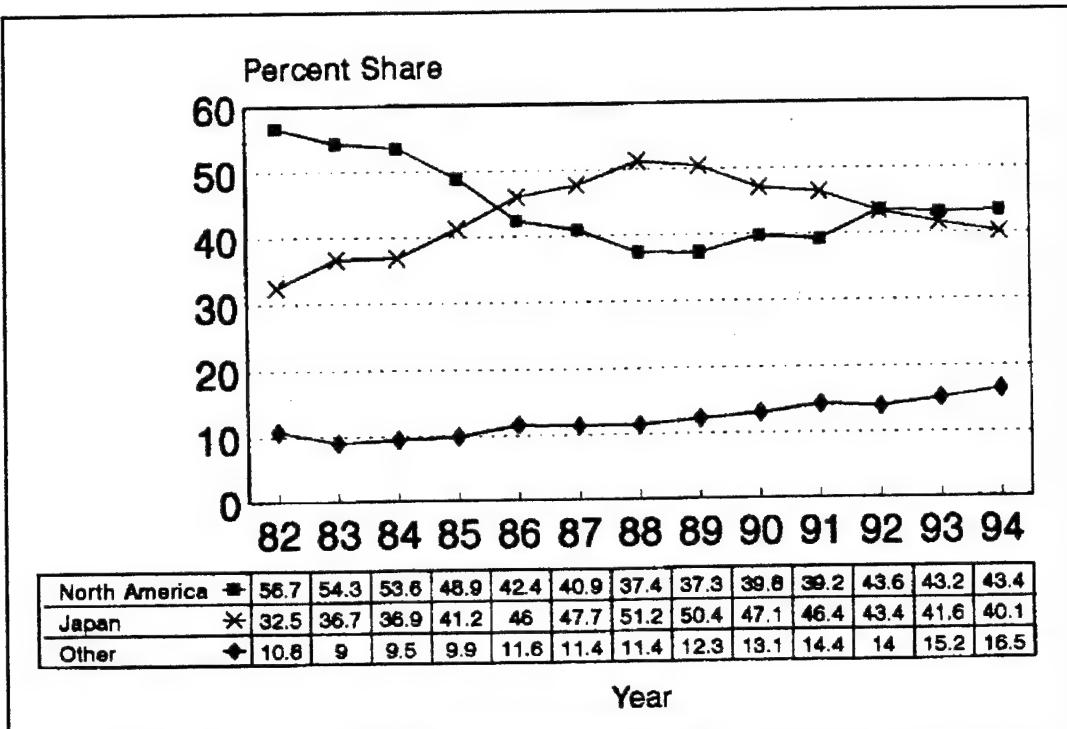


Figure 12. World Semiconductor Market Share by Producing Region

Asian-Pacific region, excluding Japan, which was up about 23 percent. The Japanese semiconductor market improved somewhat in 1993 from the sharp decline in 1992. [Ref. 78] Figure 12 illustrates the market shares of the world semiconductor market by producing region. [Ref. 79]

2. Related Devices and Other Active Components

Power and special-purpose tubes, including microwave tubes, are used primarily for radio frequency applications in military products, and declining defense budgets are likely to have an adverse impact on their markets. Conversion to dual-use technology will be the key to future sales growth of these tubes. Power tubes are being phased out to some extent and replaced by power semiconductors. Consequently, the market is largely dominated by demand for spares and replacement parts.

Microwave tubes account for almost 40 percent of the overall power and special tube market in the U.S. Microwave tubes are used primarily in high and ultrahigh frequency applications, especially in radars, missiles and communications systems. DoD-

critical traveling wave tubes, a type of microwave tube, accounted for about 66 percent of microwave tubes produced in 1992.

In 1992, tube imports grew 14 percent, to \$928 million, while exports remained nearly level at \$771 million, resulting in a trade deficit of \$157 million. Japan is by far the largest tube exporter to the U.S. market, with \$591 million, or 63 percent of total U.S. tube imports in 1992. Other large exporters of tubes to the U.S. are (in descending order of importance) Mexico, Taiwan, France, Germany, and the United Kingdom. In the first half of 1993, imports from Italy grew a dramatic 350 percent from a year earlier, while imports from the United Kingdom rose 24 percent. [Ref. 80]

3. Semiconductor Manufacturing Equipment (SME)

The SME industry makes the equipment used in producing semiconductors. The industry can be divided into three categories: wafer processing equipment; test, material handling and process diagnostics equipment; and assembly equipment. The U.S. attained a 51 percent share of the world SME market in 1993, with U.S. sales at about \$6 billion. Japan's share of the market was 41 percent, down from 45 percent in 1991. Europe and the rest of the world had about 8 percent.

Worldwide sales of SME increased an estimated 17 percent in 1993, to \$11.9 billion, following a 3 percent decline in 1992. These worldwide sales were also accompanied by expanded domestic sales in 1993. The U.S. had the largest market in 1992 and 1993, purchasing about 37 percent of all SME. Domestic sales of U.S.-produced equipment increased an estimated 20 percent, to \$3.6 billion, in 1993. About 59 percent of U.S.-produced SME is sold to the domestic market. [Ref. 81]

a. Wafer Processing Equipment

Wafer processing equipment includes the equipment for deposition and diffusion, lithography, ion implantation, and etching and cleaning. This type of equipment accounts for almost half of SME sales, and was valued at \$4.6 billion in 1992 and an estimated \$5.5 billion in 1993.

Spending on deposition and related equipment was an estimated \$1.9 billion in 1993, and accounted for 34 percent of spending on wafer processing equipment. Deposition equipment is used to deposit or develop materials on wafer surfaces. These layers form the wires and insulators that interconnect the transistors of the device. The U.S. is much stronger in deposition and related equipment, which will experience strong growth rates in future years.

Deposition equipment is growing in importance for many reasons. The most significant factor is the shift to multi-level interconnect processes, which continue to increase as device sizes shrink and chip integration levels rise. When density per chip increases, additional layers of metal interconnect are needed to handle the added throughput on a chip. Many chip companies are shifting toward production of higher value-added ASIC's and complex logic products.

Lithography equipment, used to pattern circuits on wafers, has traditionally been the most important piece of wafer processing equipment, because of its ability to deal with smaller dimensions. However, worldwide sales of lithography equipment dropped 24 percent in 1991, and 8 percent in 1992, to \$1.3 billion. In 1994, several U.S. companies, including IBM, AT&T and Motorola, formally launched a collaborative effort to share the development costs needed to bring new x-ray lithography technology into productive use. In addition, x-ray lithography has been encouraged by DoD's need for high-performance chips.[Ref. 82]

b. Test, Material Handling, and Process Diagnostic Equipment

Equipment used to test, handle material, and diagnose processes comprises about 30 percent of SME. It was valued at \$2.5 billion in 1992 and about \$2.9 billion in 1993. Japan and the U.S. consumed equal amounts (about 35 percent each) of test, material handling, and process diagnostics equipment in 1992. The U.S. has a clear lead in all categories of automatic test equipment, except for memory test systems. Japan had a 66 percent share of the \$247 million memory test system market. U.S. companies dominate in mixed-signal testers and logic test systems, worth a combined \$818 million in 1992. Sales by U.S. companies of mixed-signal and logic-test systems reached \$607

million. Although Japan has a larger share of the material handling equipment market, the U.S. is particularly strong in laser repair equipment, which should experience future growth because of its use in the production of advanced semiconductors and flat-panel displays. In the process diagnostics market, the U.S. is strong in instruments that measure film thickness, wafer flatness, and detect defects.[Ref. 83]

c. Assembly Equipment

Assembly equipment accounts for a smaller share of SME, but since 1988 has been experiencing higher annual growth rates than the other two sectors. Worldwide consumption of assembly equipment was \$945 million in 1992 and about \$1.1 billion in 1993. In assembly, various bonding processes are used to connect wires between film-circuits and silicon chips. The processes used depend on the type of semiconductors being produced. Europe is strongest in the die bond equipment market. The U.S. leads in manual wire bonding. Japan has a 53 percent share of the automatic wire bonding market. Automatic wire bonding equipment accounted for half of the \$402 million in sales of bonding and inspection equipment. Japan dominates the tape automated bonding market worldwide, with a 75 percent share. Tape automated bonding is expected to increase at a high rate through 1998. Flip chip bonding can be used in the production of DoD-critical multi-chip modules. The flip chip bonding market is still small at about \$8 million, but is expected to grow at an average annual rate of 25 percent through 1998. The largest assembly market, packaging equipment, increased sales by an estimated 20 percent in 1993, to \$543 million. The U.S. has a 34 percent share of this market. Table IX summarizes the U.S. and Japanese market shares in each SME category. [Ref. 84]

d. Future Trends

Production equipment for multi-chip modules is expected to experience a healthy market. Multi-chip modules are receiving considerable attention from industry and the Government. Consortia have been formed, and ARPA has provided funds for the development of this industry, trying to foster an appropriate infrastructure. Multi-chip modules are already established in high-performance and consumer markets.

<u>ITEM</u>	<u>U.S.</u>	<u>JAPAN</u>
Wafer Processing	51	41
Test, Material Handling, Process Diagnostics	45	45
Assembly	31	46

Table IX. U.S. and Japanese Market Shares of the World SME Markets

In 1992 and 1993, as a result of the recession in Japan and increasing competitiveness of the U.S. semiconductor industry, the Japanese bought 33 percent of all equipment. U.S. and Japanese semiconductor companies buy about 80 percent of their equipment from their domestic suppliers, so the downturn in Japan more adversely affected Japanese suppliers than their U.S. counterparts.

The outlook for SME continues to be encouraging, with expected demand growth as high as 25 percent, the strongest growth since 1988. Semiconductor companies around the world are making capital expenditures to prepare for future generations of high-memory chips. The 256 megabyte memory chip generation is on the horizon, but many issues remain unresolved regarding next generation technologies. New fabrication facilities are being built, while current plants are operating at full capacity. Texas Instruments, Motorola, Intel, AMD, and Digital Equipment have announced plans to construct (or are already constructing) new facilities in the U. S. indicating high confidence in the future growth of global semiconductor markets.

The DOC expects sales of U.S. equipment to continue to increase through 1998 at a compound annual growth rate of about 13 percent. After the high-volume years of 1993 and 1994, sales growth will become more moderate. The rising cost of plant facilities has become a crucial factor. Partnering by semiconductor manufacturers, which will reduce the total available market to equipment suppliers, will heighten competition among equipment producers. Partnerships in the SME industry also will take place in order to gain access to new or difficult markets, allow each company to benefit from the

other's technological expertise, and lower R&D costs related to the introduction of new products. [Ref. 85]

F. RAW MATERIALS

The Bureau of Mines and the DOC oversee relevant industries to ensure that the Government has current information on the defense industrial base. Major revisions of the National Defense Stockpile have recently occurred. In May 1993, DoD reported to Congress that only the following materials were now considered critical:

- Beryllium metal
- Chromium metal
- Natural Ceylon amorphous lump graphite
- Jewel bearings
- Mercury
- Phlogopite block mica
- Palladium platinum

As part of the restructuring of the stockpile, Congress has authorized disposal of commodities valued at \$3.5 billion. Of the 92 raw materials in the National Stockpile in 1993, 41 were authorized for total disposal and 15 for partial disposal. Thirty-six raw materials were ordered to remain stockpiled, including the 7 DoD-critical materials.

Canada and Mexico, the two largest sources, provided 31.6 and 9.2 percent of the imports of metals and industrial minerals in 1992, respectively. Other sources filling demands of U.S. metals and industrial minerals were as follows: the European Community, 3.2 percent, Japan, 0.5 percent, East Asian countries, 5.7 percent, South American countries, 17.9 percent, and other regions made up 31.9 percent. [Ref. 86]

G. VENDOR SURVEY

A survey was conducted of semiconductor and electronic component businesses to substantiate the trends presented by previous studies. Questionnaires were electronically sent to over 100 businesses listed on *Hoover's Business Database* as being in the semiconductor or defense electronics business. The *Hoover's Business Database* is available on most commercial online services. Thirty-three responses were received. The objective of the survey was to validate existing literature and previous studies and to attempt to gain an insight of the lower tiers of the vendor base. In addition to the small sample size taken, the survey is limited by the fact that the vendors were not segmented into specific types of items produced. The survey and results are listed in Appendix C.

The effects of the use of offset agreements was noted as a reason for the use of foreign sources. All of the respondents noted that defense-related work accounted for less than 25 percent of their business. Of the 33 respondents, 31, almost 94 percent, replied that they use foreign sources. South Korea was cited by 11 of the respondents as the country that had their largest foreign source, Japan was second with nine, Taiwan was third with two, and Denmark, the Netherlands, Singapore, Hong Kong, and the Philippines were each noted once. Some firms responded that they could not cite a specific country, for their sources vary frequently.

When asked how many countries were represented in their foreign vendor base, two firms replied with one country, seven replied between two and four countries, 21 replied five to six countries, and one noted over 10 countries. Several respondents noted that more than one of their foreign sources were located in the same country. For example, one respondent listed South Korea three times indicating that three of the firm's four largest sources were located in that country. Figure 13 details the number of the responses each country received when the firms were asked to name the countries represented by their four largest foreign sources.

Eleven firms replied that they do not anticipate any difficulties if North America were cut off from overseas sources. Problems in getting subcomponents and materials

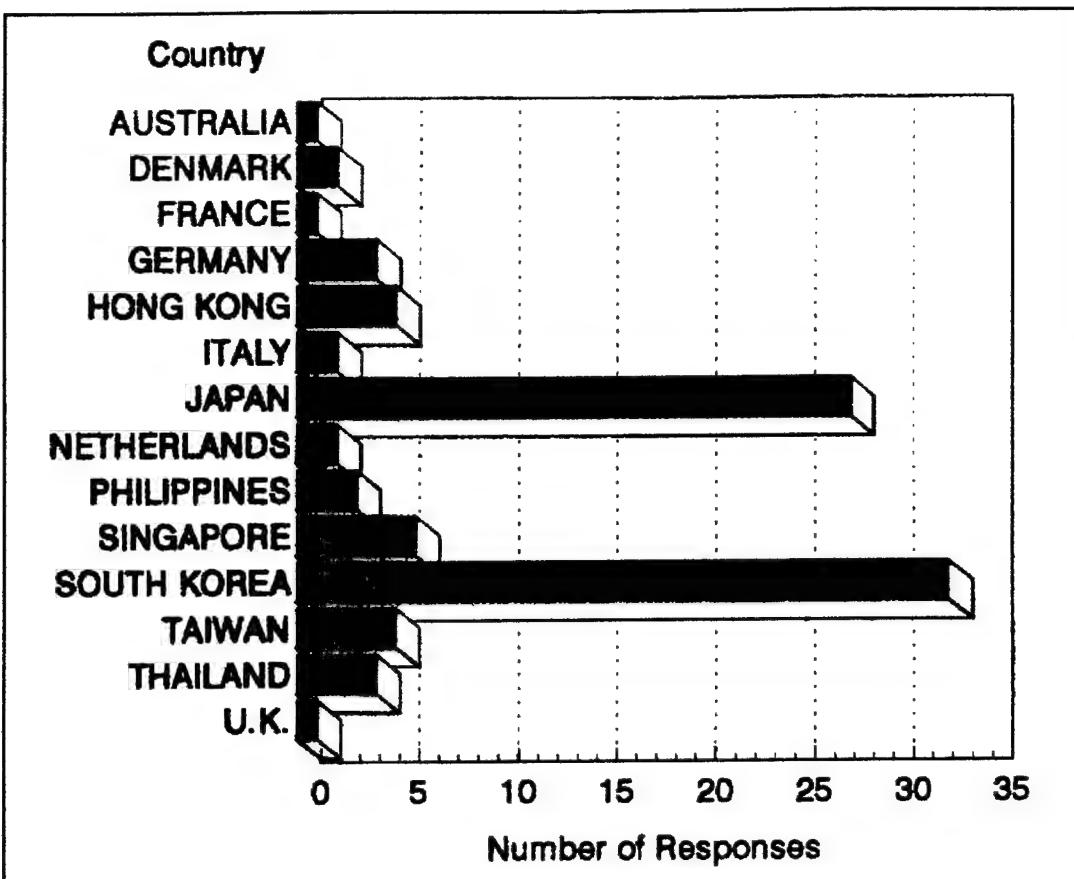


Figure 13. Countries Represented by Respondents' Four Largest Foreign Sources

were noted nine times as being a potential source of difficulties. Next, problems in accessing overseas production processes and problems in obtaining domestic transportation were each noted seven times. Problems in repairing foreign-made machinery and problems in the quality of domestic items were each noted twice.

All 33 of the respondents estimate that they would be able to increase production using present sources and equipment up to 25 percent in 60 days or less. However, 28 respondents anticipate being able to surge production by 26 to 50 percent in three to four months. In the five to six-month timeframe, the respondents are almost equally divided in their estimates. About a third estimate that they could surge 25 to 50 percent, another third cite 51 to 75 percent, and the final third put their surge potential at 76 to 100 percent.

When asked if the largest foreign source could be replaced by a domestic source within 30 days, 27 respondents replied affirmatively. This assumed that cost and the Government qualification process were not considerations.

The lower cost of foreign-made products was cited by 15 respondents as the reason that prompted their use of foreign sources. Eight respondents noted that the unavailability of domestic sources prompted their use. Offset agreements were cited by three respondents and contractual obligations prompted two respondents.

Thirty respondents noted that they provide information to DoD and contractors on their use of foreign sources. Thirty-two respondents did not feel that the use of foreign sources was a threat to national security.

H. PROGRAM MANAGEMENT OFFICE INTERVIEWS

Officials from seven Program Management Offices of U.S. Army missile systems were interviewed. All of the weapons systems are in production, except one which is no longer in production, but had been in production for many years. These officials were asked about their knowledge of the use of foreign sources in the production of their respective weapon system, their visibility into their lower-tier subcontractor base, and their management of the use of foreign sources. From the interviews, some common causes for foreign sources were mentioned. Finally, the opinions of those interviewed concerning whether the use of foreign sources threatens their systems' ability to meet the surge requirements in the event of a national emergency were solicited.

When asked whether they knew of any foreign sources used in the production of their missile systems, the responses indicated that five systems presently use foreign sources, and two others had used foreign sources in the past. Two missile systems were presently experiencing foreign-source related problems. The production of one system had ceased due to problems with IC's imported from the Philippines and processed by a California-based firm. According to the PM, the domestic firm was repackaging the foreign-sourced IC's to its own label, and was having process control problems. Another system was working a foreign-source dependency problem. In the past, the thermal

battery for the missile had been produced by only one domestic producer. The domestic producer went out of business and sold its technical data package to a producer in France. The PM Office was in the process of qualifying the French firm. In addition, a domestic source was sought and is presently going through the qualification process.

All seven of the PM Offices reported that they do not have visibility beyond their key subcontractors, mostly at the first-tier subcontractor level. In addition, visibility into the lower-tiers only occurs as a result of a problem.

All of the PM Offices responded that they manage the use of foreign sources on a "by exception" basis. PM Offices get involved only when a problem arises involving either the loss of the sole domestic source, or a technical problem arises involving a foreign source. However, several of the officials interviewed expressed their sensitivity to the use of foreign sources becoming a vulnerability, and that they would take appropriate actions to counter vulnerabilities. A common view expressed was that a foreign source should not be the only source.

Three of the missile systems use foreign sources as a result of offset agreements that are a part of their FMS programs. Two other respondents noted that although they do not presently have a FMS program for their system, they expect offset agreements and foreign-source use when they do begin FMS.

One PM cited partnerships among vendors as a cause of foreign-source use. He noted that these partnerships "muddy the waters" in identifying foreign sources used. As mentioned earlier, a vendor going out of business and selling its data package to a foreign firm caused an foreign-source dependency for one system.

All of the respondents whose systems were still in production felt that their system could meet surge requirements in the event of a national emergency, such as an MRC. The system not in production expects to meet contingencies from current stocks. None of those interviewed felt that foreign-source use is a threat to their ability to meet surge requirements.

VI. ANALYSIS

Moran and others have stated that the extent of the use of foreign sources is unknown, because the currently available data does not permit a detailed, quantitative evaluation. The DSMC noted that a comprehensive analysis of foreign-dependency issues for the defense industrial base has not been performed, due to the lack of: (1) viable production information, (2) adequate analysis methodology, (3) specific guidance and monitoring by PM's and the Army. While the data does not allow for an accurate calculation or estimate, one might reasonably conclude that foreign-source use is a mix of threats and non-threats to national security. The finding by the Navy and Commerce Departments that 20 percent of the examined weapons systems' parts were made overseas provides the only numerical estimate of the extent of the use of foreign sources. However, there are several indicators that can be used to infer whether foreign-source dependencies are increasing or decreasing. These indicators include Government (including PM's) attention to the issue, trends in Government and commercial R&D, trends in DoD procurement, and defense industrial base conditions.

Dependencies on foreign-sourced semiconductors or IC's are generic to all PGM's. As noted previously, the most critical potential problems arise as a result of the loss of pervasive items, subcomponents that are common to multiple systems. Studies show that the most significant concentrations of foreign technology sources were in microelectronics, and they reveal an increasing trend. Studies also indicated a heavy dependence on a few foreign sources in certain mature technologies. The tools for evaluating foreign-source uses will be applied to the various industries and examined for their applicability for Government use. The different approaches will then be compared to each other.

A. GOVERNMENT MANAGEMENT OF FOREIGN-SOURCE USE

The literature reviewed noted that acquisition officials must become more cognizant of the foreign-dependency issue and they need to be well prepared to identify, evaluate, and manage foreign-source dependencies and their associated risks. Even

though DoD Directive 5000.2 directs that program plans include procedures to identify and minimize potential foreign dependencies, DSMC noted that PM's and other acquisition officials have expressed two consistent views. First, industrial base programs have secondary priority when compared to cost, schedule and performance. Second, PM Offices have limited resources and must accomplish many objectives. These views help prevent realizing the visibility needed to identify and manage foreign-source dependencies.

Interviews of Army missile system PM Offices revealed that two of the seven systems examined were experiencing foreign-source related problems. All seven of the PM Offices reported that they generally do not have visibility beyond their first-tier subcontractors. All of the PM Offices responded that they handle the use of foreign sources on a management-by-exception basis. Visibility into the lower-tiers only occurs as a result of a problem.

Manufacturing strategies must address foreign-source dependencies, for actions taken early in the acquisition process have the greatest effect on the problem. In addition, surge and mobilization capabilities are required to be evaluated during Milestone II and III reviews. However, the cited dearth of visibility into the vendor base constrains the PM from fulfilling the full extent of Government directives.

The requirement and pressure for full and open competition is cited as one cause of the foreign-dependency problem. Even though, the FAR authorizes exceptions to full and open competition, research indicates that contracting officers often are not given guidance or clear criteria in using this exception. Therefore, it is possible that contract management officials do not monitor and report foreign-source use as often as they could.

B. CRITICAL TECHNOLOGIES AND PROCESSES

The PBA created the CIL that consists of 24 technologies and processes that DoD has determined to be critical. Critical is defined as "being absolutely necessary for the continued viability of the missile industry." The Army Data Collection Plan (DCP) is being carried out to collect data on the products in the CIL and their producers. The

DCP is being used to develop the IPPL that identifies items for which the industrial base will be protected. As noted before, of the 175 missile-related items listed in the IPPL, 169 items are at the levels where the key activity is assembly, product levels one through three. Figure 14 is a graphic representation of the between product levels and processes. In addition, DoD presently considers seven raw materials as critical, but none are listed in the Army missile IPPL.

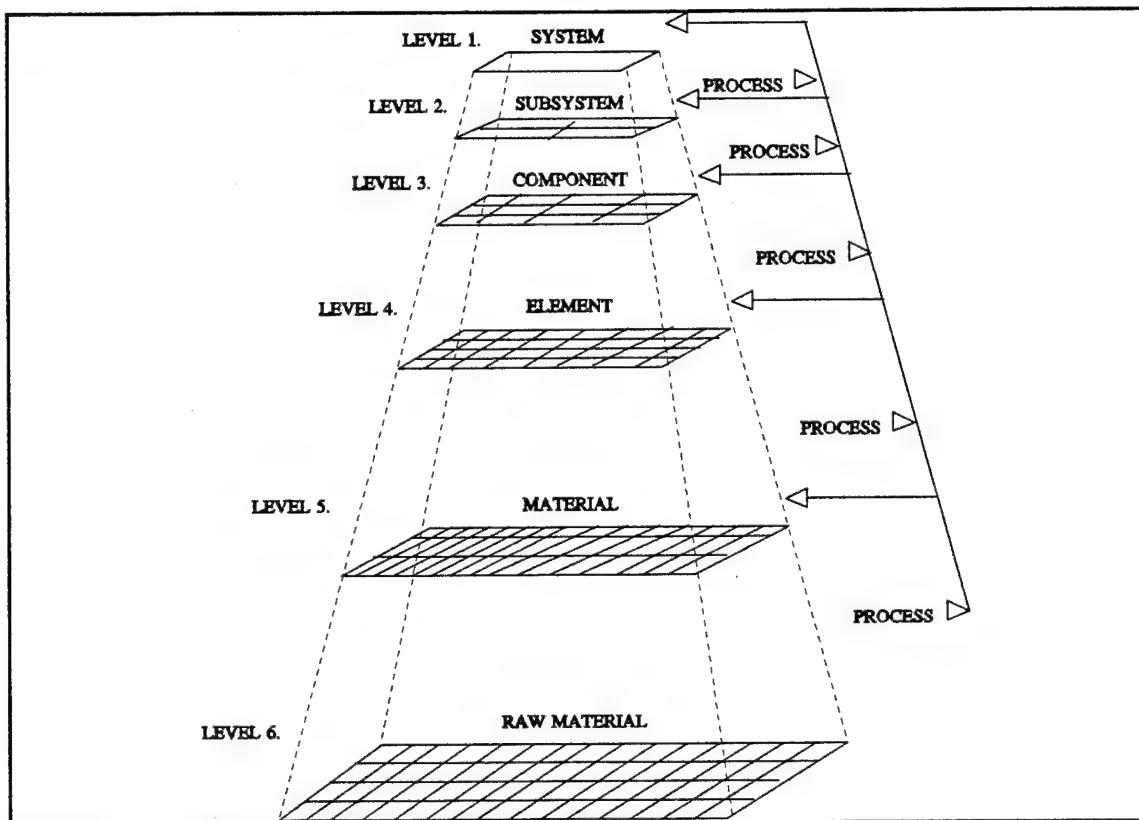


Figure 14. Product Levels and Processes

The IPPL is limited, for it does not examine all of the technologies and processes used in missile production to determine whether they are foreign-sourced and can cause bottlenecks in the flow of resources. Most of the attention is given to products that are assembled and not to elements and materials, such as semiconductors, and the processes used to produce elements and materials. Decomposition of a system into identifiable items occurs in developing the Work Breakdown Structure (WBS) commonly used by PM

Offices. The decomposition necessary to identify all potential foreign-source technology and process dependencies that could cause production bottlenecks, may exceed the WBS in detail.

Not all processes that cause bottlenecks are considered critical by DoD. However, there are some processes which use technologies that are available domestically, but involve some inputs (materials, elements, equipment) that are foreign-sourced. Figure 15 portrays a fundamental process.

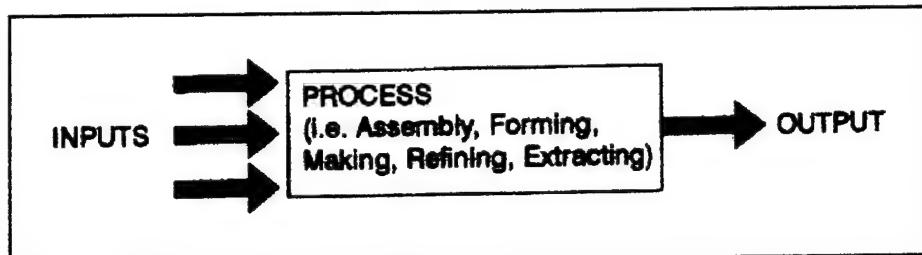


Figure 15. Basic Model of a Process

One example of the above is a process known as Chemical Vapor Deposition (CVD). CVD is a state-of-the-art process used in the production of some DoD-critical semiconductors, such as application-specific integrated circuits (ASIC's). The U.S. leads the world in CVD technology, with domestic firms owning a 75 percent share of the world market for CVD equipment. A critical step in the CVD process involves ozone being bubbled through several liquified chemical elements before being deposited on the silicon wafer surface. The ozone used is generated commercially. The only source of ozone in the world is in Kobe, Japan. On January 17, 1995, the city of Kobe Japan was devastated by a major earthquake. The earthquake was the second worst in Japan's history, destroying 88,000 buildings. Fortunately, the ozone production facility was not damaged, but much of the city's harbor, Japan's largest, was severely damaged and the flow of goods out of the city was constrained. [Ref. 87] Although the U.S. is dominant in CVD technology and CVD equipment manufacturing, an unacceptable foreign-source dependency exists, making the U.S. vulnerable to loss of access. A thorough examination of all processes and items used in production of products at all levels is required to fully measure foreign-source use.

C. RESEARCH AND DEVELOPMENT

1. Government R&D

As noted previously, national defense has become a secondary priority for Government support of R&D. Historically, national security concerns dominated R&D policy, but the most important emerging focus for current Government programs has been to support R&D to increase industrial productivity and competitiveness. Adjusted for inflation, the Government's R&D expenditures have fallen 7 percent since 1988. The projected 1996 through 1999 federal budgets reduce R&D funding by about an additional 25 percent by fiscal year 1999. This would bring annual R&D funding to a level below the average of the past 40 years and well below the average of the past decade. This is in spite of the rapid technological changes presently being experienced. U.S. long-term technological superiority could be adversely affected by this reduced Government R&D. As one of the consequences, increased foreign-source dependencies may result.

2. Commercial R&D

Spending on commercial R&D is increasing, but its growth rate is declining as a percentage of production. It appears from the data that private-sector R&D spending may be leveling.

Sixty percent of the respondents to a GAO survey expressed the opinion that legislation designed to steer IR&D/B&P toward critical technologies has had little or no effect on the work being performed related to dual-use technologies. Firms are motivated by profits and quicker returns on investment.

Seventy-six percent of the contractors reported that they spent less than 40 percent of their IR&D/B&P expenditures on the goals listed in the DoD Critical Technologies Plan. The firms reported that 69.1 percent of IR&D/B&P expenditures were on near-term developmental projects aimed at designing, developing, or testing a new or improved product. Applied and basic research comprised 26.6 and 4.3 percent of the firms' IR&D/B&P expenditures, respectively. Basic and applied research projects tend to involve more risks and require more time to realize a return on investment. Coupled

with reduced Government R&D expenditures, the smaller-than-expected private sector R&D of technologies critical to DoD could threaten the long-term technological superiority of the U.S. and may promote an increased reliance on foreign technologies.

MNE's tend to concentrate R&D in the country of national origin. American-based MNE's conduct less than 13 percent of their manufacturing R&D abroad. Foreign affiliates account for a small, but increasing, share of all R&D spending in the United States; rising from 9.4 percent in 1982 to 16.4 percent in 1992. Much of this growth, however, resulted from foreign acquisitions of U.S. firms in the late 1980's. The Office of Technology Assessment's (OTA's) analysis of these trends indicates that the degree of R&D internationalization is still relatively low. The more R&D that is conducted domestically, regardless of company ownership, the less the risk of loss of access to new technologies.

D. INVESTMENT AND R&D IN THE SEMICONDUCTOR INDUSTRY

Increased R&D spending in recent years has been credited as the reason for America's return to world leadership in market share and technological advances in the semiconductor industry. Alliances have become more numerous between domestic companies; therefore, private sector R&D will probably remain in the United States. In addition, increased foreign R&D within the U.S. is a positive condition.

High capital costs in the semiconductor industry are a major issue. These costs have caused firms to adopt various strategies to cope with the cost of ownership. Alliances and the specialization of individual firms have promoted foreign-source use and complicated Government examination of the industry. In addition, the reduced capital investment trend among semiconductor firms could lead to a capacity shortage, especially in times of surged production, lower productivity and eventually higher costs.

E. GOVERNMENT PROCUREMENT

The 1995 Army missile procurement budget was 45 percent smaller than 1994's. The total DoD procurement budget has been reduced by 66 percent from 1985 to 1995.

According to the Administration's plan, funding for procurement would begin to modestly increase within a few years and would exceed \$50 billion (fiscal year 1995 constant dollars) by fiscal year 1999. The severe reductions in Army missile procurements threaten the health of the Army's missile industrial base. Cyclical defense budgets have been a chronic defense industrial base problem. A 45 percent reduction in one sector's procurement budget can reduce the number of available contractors in the long-term. The AMC sector survey noted that the missile industrial sectors had some firms that were heavily dependent upon DoD and that the sectors were in need of support. Additionally, during periods of such tight budgets, acquisition officials and contractors could overemphasize lower costs and unwittingly promote foreign-source use.

F. THE DEFENSE INDUSTRIAL BASE

The number of domestic prime and lower-tier defense contractors is diminishing. As defense contractors go out of business, more of the vital defense technologies are being bought from foreign sources. Prime contractors and lower-tier suppliers are quite different in many respects, such as the way in which business is done, the basic industrial structures, and the problems at the technical level.

The AMC industrial base sector survey noted that both the small and large missile sectors were categorized as acceptable (stable, but were in need of some support). The survey determined that there are large segments of the sectors that are military-unique and/or totally dependent on defense business. The survey also noted that there has been a shrinkage of the vendor base and that many contractors are leaving the defense business. Off-the-shelf technologies were being considered for integration into existing weapon systems.

According to the PBA, steady missile sector production is a positive indicator that the industrial base probably could surge critical spare and repair parts manufacturing and maintain critical contractor expertise. Of the 11 items in production, seven had FMS in fiscal year 1993. FMS has served to keep many production lines warm. FMS and Strategic Defense Initiative Organization programs are projected to sustain the missile

sectors after many production lines cease deliveries to the U.S. armed forces. Three of the missile system PM Offices indicated that the use of foreign sources is a result of offset agreements that are a condition of their FMS programs. Two other PM Offices noted that although they do not presently have an FMS program for their system, they expect offset agreements and foreign-source use when they do begin FMS. A trade-off exists with FMS. FMS keeps production lines warm, but promote foreign-source use.

An estimate of plant capacity utilization rates for missile, electronic components and semiconductor production facilities indicates that the U.S. possesses the capacity to produce these products during full mobilization and national emergency conditions. One can infer that active production lines enable firms to maintain emergency production capacities much easier.

MNE's are critical to ensuring the health of the U.S. technology base. The examination of MNE's is important to the study of the foreign dependency. They have an increasingly global outlook. According to the OTA, foreign affiliates of MNE's control a substantial portion of the world economy, perhaps as much as one fourth of all economic activity in their host countries. Intrafirm trade (IFT) may account for as much as 40 percent of all U.S. merchandise trade. Many MNE's now employ global marketing strategies which target selling more abroad than at home. An increasing number of MNE's source a significant share of their parts through international channels, and many have located major production facilities in foreign countries. A growing number of firms from different nations enter strategic alliances to pool financial and technological resources, and to gain access to foreign markets.

The U.S. exports five times more technology than it imports, and most of this trade is done within MNE's. Affiliates of foreign-based MNE's account for a substantial share of U.S. merchandise trade and the greatest portion of the U.S. merchandise trade deficit. Affiliates of foreign-based MNE's tend to import more than do domestic firms. IFT figures indicate that the majority of U.S. trade with Japan takes place within affiliated networks dominated by Japanese firms. MNE's, especially U.S.-Japanese

MNE's, merit special attention. It may be cost-effective to examine products purchased from these MNE's for unacceptable foreign-source dependencies.

1. Prime Contractors

Prime contractors' annual sales cumulatively capture around 50 percent of DoD's procurement dollars each year. The defense industry is relatively concentrated. The top 100 firms consistently do about 75 percent of the business, and most of the defense firms tend to specialize. This specialization, combined with declining defense budgets and Government practices, results in higher concentration ratios for selected weapon areas than are found in typical commercial sectors. Another distinguishing characteristic of the defense business is the barriers to entry and exit.

To produce complex, high-quality, low-cost systems requires very modern automated manufacturing equipment. The problem is that there are inadequate incentives to encourage defense firms to make the long-term capital investments necessary to drive down costs and improve quality. Capital investment among defense contractors trails that of the commercial sector by as much as 50 percent. The average profit for the defense industry is about half of that achieved by companies not heavily reliant upon DoD, around one-third of that of exclusively commercial firms, and about 25 percent less than that of durable goods manufacturers. Capital investments help improve productivity that, in turn, reduces costs and increase profits. Lowering costs will enable U.S. firms to effectively compete with foreign firms and help alleviate one of the major causes of foreign-source use.

A significant trend (that is likely to increase) is the teaming of defense contractors to bid on the few available contracts for weapon systems. Prime contractors are often encouraged by the Government to team up so that they will be able to share the high investment risk, as well as to keep a large number of them in the business. In these teaming arrangements, several prime contractors become subcontractors to one another on various parts of a weapon system. Another trend is unrationaled mergers among defense contractors. These firms traditionally treat each of their plants as an entity with its own engineering, marketing, and management staffs. Teaming arrangements and

unrationalized mergers do not reduce costs, but can reduce competition and innovation. All of these consequences foster foreign-source dependencies.

2. Subcontractors and Part Suppliers

As the defense budget is reduced, policy-makers face a number of critical issues related to both preserving technological leadership and ensuring the existence of the industrial base capabilities required to meet the national security needs. The *Defense News* survey shows that 56 percent of the firms responded affirmatively when asked if they are finding that key subcontractors are leaving the defense business. In addition, the survey shows that prime defense contractors are limiting the number of subcontractors they use. This trend has been accelerating. Some researchers contend that prime contractors are focusing on the best value from a small number of experienced firms instead of a large number of bids from many potential subcontractors. Sixty-seven percent of the firms surveyed indicated that they are trying to reduce the number of subcontractors they use. Forty-two percent of the prime contractors indicated that they are doing more work in-house. A reduction of the domestic subcontractor base can lead to foreign-source use and a long-term shortage of surge capacity.

Legislation, regulations, policies, and procedures are primarily written for prime contractors. Prime contractors pass many of these requirements down to their subcontractors. This heightens the existing problems and differences. A typical defense prime contractor subcontracts between 40 and 75 percent of a weapon system's work. Even though, small firms have made many of the breakthroughs in military technology, DoD has historically ignored the lower levels of the defense industry by assuming that the prime contractors would ensure their continued viability. Research indicates that prime contractors do not show much genuine concern about the viability of lower-tier suppliers and subcontractors. Thus, many firms have been exiting the lower tiers while commercially-oriented firms have not been entering. The AMC sector survey also noted this trend. The result is a deterioration of the subcontractor base, both in terms of numbers and in terms of a growing dependency on foreign producers. In addition, research indicates that firms are discouraged by the many barriers to entry. Only a few

suppliers remain in the lower tiers of the defense industry, and they are forced to specialize. The specialization of these firms is contrary to the Government's desire to integrate the defense and commercial sectors of industries.

Almost 94 percent of the respondents to the vendor survey acknowledged that they use foreign sources. Of the vendors surveyed, 70 percent indicated that they use foreign sources from five to six countries. South Korea and Japan had 77 percent of the foreign sources used by the vendors. Some firms responded that they could not cite a specific country, for their sources change frequently.

All of the respondents estimate that they would be able to increase production up to 25 percent in 60 days or less using present sources and equipment. In addition, 85 percent of the respondents anticipate being able to surge production by 26 to 50 percent in three to four months. These responses indicate that the vendors are confident in their foreign sources' reliability and capacities. Another good indication was that 27 vendors claimed that they could replace their largest foreign source with a domestic one within 30 days. This assumed that cost and the Government qualification process were not considerations.

The lower cost of foreign-made products was cited by 15 respondents as the reason that prompted their use of foreign sources. Eight respondents noted that the unavailability of domestic sources prompted their use. Offset agreements were cited by three respondents, while contractual obligations prompted two respondents.

Almost all of the respondents felt that the use of foreign sources was not a threat to national security, and all of the respondents noted that defense-related work accounted for less than 25 percent of their business. About one-third of the firms replied that they do not expect any difficulties if North America loses its overseas sources. Problems in getting subcomponents and materials were noted nine times out of the 33 respondents as being a potential source of difficulties. Problems in accessing overseas production processes and problems in obtaining domestic transportation, were each noted seven times. Domestic transportation was not listed as a difficulty, but seven firms "wrote in" this concern. One concern is that the use of foreign sources may reduce domestic

transportation capacity, and these resources may not be available to support increased domestic production. Problems in repairing foreign-made machinery and problems in the quality of domestic items were each noted twice.

G. ANALYSIS OF EVALUATION METHODS

Each of the methods for evaluating foreign-source dependencies that were presented in Chapter IV will be analyzed for their effectiveness at the PM and DoD levels of Government acquisition management. One would presume that a PM would be concerned with the one weapon system he or she is responsible for and would be sensitive to any delays in production. An acquisition official at the DoD level would, presumably, be concerned with more than one weapon system, and be concerned about potential production delays that could cause a modification to a program's budget.

A major difference between the PM and DoD levels is the timeframe being considered. A PM's outlook is more toward the short-term while at the DoD level the focus is more on the long-term. The risks of using foreign sources differ, when viewed from the short versus the long-term perspective. As the timeframe expands, uncertainty increases.

A PM, presumably, would be concerned more with the short-term (less than three years) foreign-sourcing that could affect production, or lead to a lack of critical items during a crisis. These critical items would most likely be expendable items, such as missiles and spare parts. DoD's focus is beyond the short-term and on the country's ability to produce major end-items. DoD's concern is on long-term risks associated with foreign-source dependencies, such as the reliance on foreign technologies and failing to maintain technological superiority. Therefore, each level would have a different definition of criticality.

1. The Analytic Science Corporation Methodology

To analyze TASC's methodology, it will be applied to the semiconductor industry. Semiconductors can be screened using TASC's methodology which utilize factors such

as essentiality, the ability to reconstitute once lost, and the rate of technological change. Semiconductors would require further examination in the TASC model.

The quantitative assessment using the HHI to measure market-vulnerability requires detailed data concerning the semiconductor industry in the U.S., as well as other nations. The market-vulnerability measurement requires knowing the market share of individual firms in a particular industry. This data was not available for this study; however, a limited assessment of market-vulnerability can be performed.

The market-vulnerability HHI is the sum of the squared market shares of individual firms in a particular industry. For example, there are two extreme conditions in a market, a monopoly and perfect competition. In a monopolistic condition, there is only one firm. On the other hand, in a perfect competition condition there are as many firms as the market can support. Market-vulnerability HHI's could be plotted according to the possible number of firms given a certain total market share for a producing region. Using the "world market share by producing region" data in Chapter V, the market-vulnerability HHI was plotted in Figure 16 for situations where the U.S., Japan and other nations as a group each had increasing, but equal number of firms. Treating semiconductors as one commodity, if the U.S., Japan and the total of other nations each had four producers of equal market share within their respective producing regions, the semiconductor market could be considered secure.

The geographic HHI measures the vulnerability of the U.S. either to delay or denial by each producing region or country. Figure 17 is a graph with the geographic HHI for Japan and other nations as a group for the years 1990 through 1994. Other countries, even when treated as one producing region, do not pose a threat of collusive activity. According to the geographic HHI, the U.S. was vulnerable to delay or denial of semiconductors by Japan until 1992. Since 1993, the geographic HHI is inconclusive.

The foreign-dependence HHI measures the extent of U.S. dependence upon other nations. Using the "North American semiconductor market share" data from Chapter V, this index can be easily determined. Figure 18 depicts the foreign-dependence index from 1990 through 1994. Although the U.S. regained the lead in world semiconductor market

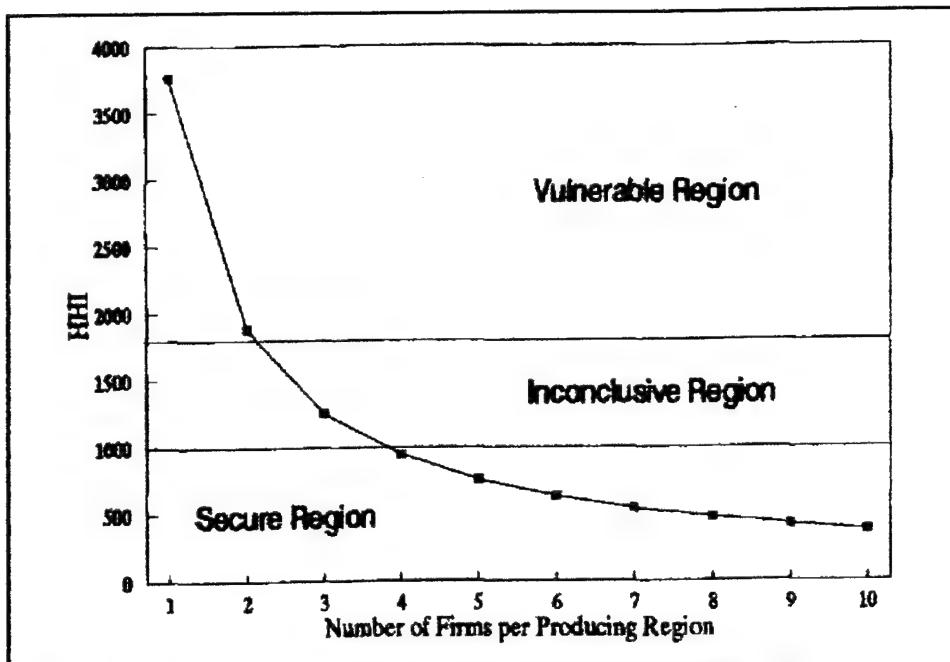


Figure 16. Market Vulnerability HHI

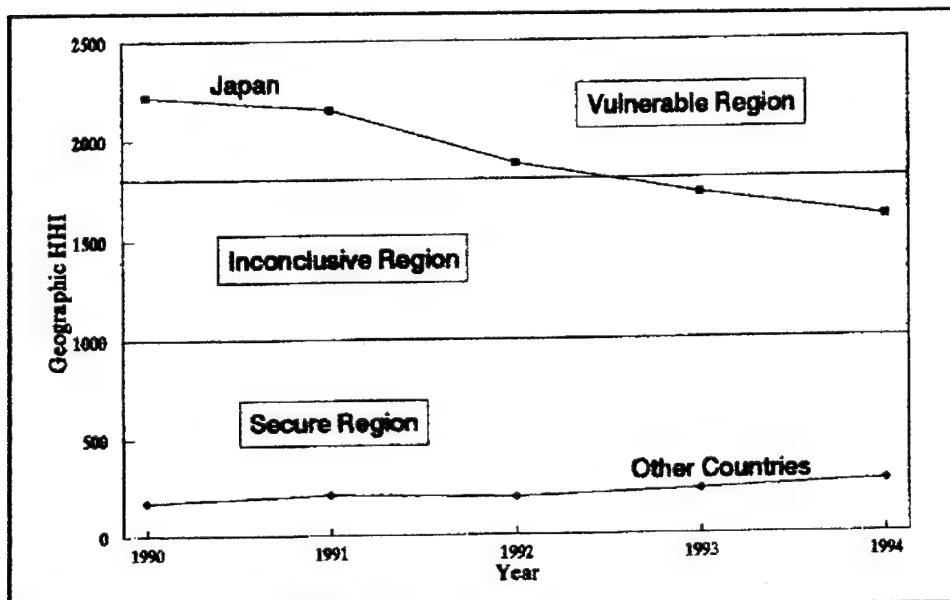


Figure 17. Geographic HHI

share, it is increasing reliant upon imports from Japan and other countries. American semiconductor production has increased enough regain world leadership, but it has not exceeded rising U.S. import demand. Overall, the U.S. is more reliant on foreign

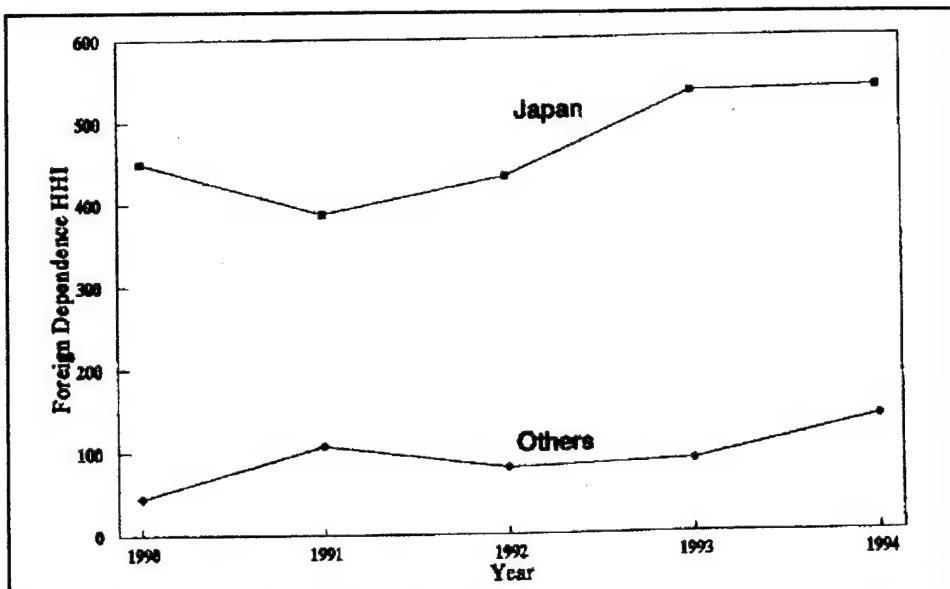


Figure 18. Foreign Dependence HHI

semiconductors today than when Japan was the world's leading producer. The entry barrier index cannot be computed, for data on international firms is not readily available.

According to the TASC approach, if the market-vulnerability HHI is between 1000 and 1800 and the five-year change in foreign market share of the American market is greater than 100, semiconductors should receive high-priority policy treatment. The HHI of foreign market share of the U.S. market in 1990 and 1994 was 494.33 and 677.85, respectively.

The TASC methodology is quite useful for acquisition officials at the DoD level. Its strength lies in its flexible screening process and quantitative approach. The data required for this type of analysis can probably be obtained by industrial specialists in other agencies of the Government, such as DOC, with reasonable effort and at an acceptable cost. The quantitative measures allow comparative and trend analyses to be performed. The ability to easily measure trends gives this approach both a short and long-term perspective.

2. DoD Evaluation Approach and the Power and Special Tubes Industry

The first step in the DoD approach requires the determination of whether a capability is essential. An essential capability is defined by DoD as one that will most likely not be available to support both defense peacetime requirements and emergency demand in the foreseeable future. DoD specifies four requirements that must be met in order for a capability to be considered essential. These requirements were detailed in Chapter IV.

Power and special tubes, including traveling wave tubes (TWT's), are used primarily for military products. TWT's are listed in the DoD missile CIL. Declining defense budgets have been noted as threatening the survival of this industry. Microwave tubes comprise 40 percent of total demand, and are used in the production of missiles. TWT's account for 66 percent of the microwave tube demand. Imports in this industry are increasing, and Japan is the largest foreign source, accounting for 66 percent of total 1992 tube imports. This industry meets the DoD's criteria of being an essential capability.

A disadvantage of the DoD evaluation process is that for a capability to meet the military mission support requirement, it must be listed in the DPG and funded in the FYDP. TWT's met this requirement. However, if a missile system were decomposed and every item and process at each product level examined, there could be several capabilities not meeting this criteria that could adversely impact production if they were lost. Some capabilities may not have substitutes available. These capabilities would not be considered essential by DoD if they were not in the DPG and FYDP. Due to this required inclusion in the FYDP and DPG, the perspective of the DoD approach is long-term.

Once this capability is determined to be essential, it must meet one of three additional criteria in order for the Government to require a domestic source. TWT's meet the requirement that it be necessary to ensure readiness and sustainment of the armed forces. Therefore, a domestic source should be required for TWT's.

3. PM Evaluation of Semiconductor Manufacturing Equipment (SME)

The PM evaluation method presented by DSMC is a three-step process. The first step in evaluating the SME industry is to determine if foreign sources are used in manufacturing the items. During this step, vulnerable materials and components are identified. Identification of vulnerable materials and components can be the result of decomposing a system into its products and processes.

There are numerous technologies and processes that are involved in producing semiconductors, such as CVD. The U.S. is dominant in most SME technologies, and consortia have been quite effective in boosting the U.S. SME industry. A notable example is SEMATECH, a Government-industry venture. However, there are some exceptions. The memory test, material handling, and automatic wire bonding equipment markets are dominated by Japan, and the die bond equipment market is dominated by Europe. During the decomposition process, a PM must determine whether SME used to produce the semiconductors used in a weapon system is dependent on foreign technologies. The CVD technology's dependency on Japanese-produced ozone is a good example.

The next step requires the PM to determine whether an identified foreign-source use could prevent an end-item from reaching its production goals. An analysis of any available substitutes should be performed. Another process or set of materials, if necessary, could replace foreign-sourced products. The first two steps require industry-provided data. The PM is in the best position to obtain data from a system's prime contractor. Finally, the PM must determine if DoD guidance exists, or is necessary, and if any action is appropriate. Some of the available remedies were presented in Chapter IV.

The PM evaluation approach is simpler than the other methodologies mentioned, and it does not require the use of any quantitative assessments. The risk assessment approach presented by the GAO could be used. This approach is better-suited for the short-term perspective of the PM, for it focuses on production and not future losses of technologies. At the PM level, pervasive dependencies, those common to many weapon

systems, are not fully measured. A reporting mechanism to centralize all PM encounters with foreign sources would facilitate higher echelon analysis and action.

4. Evaluating Raw Materials with the Moran Approach

Moran's Four-Four-50 Rule could be used to evaluate the raw materials industry. Moran's approach focuses on the concentration of suppliers as the basis for determining where threats exist. If the largest four countries or firms supply more than 50 percent of a product, and if there are neither substitutes, domestic sources, nor stockpiles, then the possibility exists for foreign sources to collude to deny or delay critical items. The Organization of Petroleum Exporting Countries's oil embargo of 1973 is an example of raw material denial.

Canada and Mexico provide a combined total of 40.8 percent of the United States' raw material imports. Few raw materials exist that are not available in North American countries. Raw materials are not dependent upon a country's advanced technologies, except for mining and exploration, like the semiconductor industry. Generally, raw materials can be imported from several sources throughout the world. Therefore, the concentration of foreign sources of raw materials is low. Raw materials can generally be stockpiled, which further reduces foreign-source vulnerabilities. In 1993, DoD decided that only 36 raw materials were to be managed in the National Stockpile, seven of which were determined to be critical to defense. This is a reduction from the 92 raw materials stockpiled previously.

Moran makes no mention of the loss of critical items due to natural disturbances, such as the Kobe earthquake. The Moran approach is better-suited for higher tiers of management, and has limited applicability at the PM level. The PM usually deals with one or two sources for items.

5. Comparison of Evaluation Approaches

The TASC approach provides quantitative measures for comparisons and trend analysis at all levels. However, it is best-suited at the higher levels of management. DoD's approach is best-suited at the national policymaking levels that have an input into the DPG and FYDP. The PM evaluation methodology is well-suited for the PM level.

Its focus is on production of a weapon system, but it does not provide for a quantitative measure. The TASC geographic and foreign-dependency HHI's could be used by a PM, if data was available to him, for trend analyses. Moran's methodology can best be used at the national level. Its strength is identifying that the concentration of sources as the basis for foreign-source vulnerabilities.

VII. CONCLUSIONS AND RECOMMENDATIONS

Each of the research questions will be examined and conclusions presented. In addition, recommendations for future actions will be offered.

A. EXTENT OF THE USE OF FOREIGN SOURCES

1. Conclusions

As stated previously, the extent of the use of foreign sources is unknown and difficult to estimate. The primary reason for the inability to do so is due to the basic lack of data required to examine the issue. However, this thesis' review of past studies and other research allows the conclusion that in spite of America's gains in productivity and competitiveness, the number of foreign-source dependencies may be increasing.

The increased globalization of present-day commerce may be beneficial economically, but requires increased awareness and management in order to prevent threats to national security. Research suggests that the Government has recognized the risks associated with foreign-source dependencies and that an increased awareness may exist in the acquisition community. However, defense industrial base issues tend to be of secondary priority relative to improving U.S. performance in the world marketplace.

The focus of Government examination of U.S. reliance on foreign sources has been on technologies critical to maintaining long-term technological superiority. Items identified by DoD as being critical to maintaining an industrial production surge capability have been mostly systems, subsystems and assembled components. Elements and materials that go into manufacturing assemblies are the items mostly produced by a vendor base largely ignored by DoD and prime contractors and whose use of foreign sources appears to be more prevalent.

2. Recommendations

To obtain the required data, a decomposition analysis of each weapon system in current production, and any additional items that must be manufactured in an emergency, should be performed. This decomposition procedure must break critical items down to the lowest product level possible. In addition, the processes involved in all levels of

production must be examined for foreign-source inputs. The prime contractor should gather this data as a contractual requirement, and the examination should be performed by the PM Office. The PM should receive sufficient funding and other resources to accomplish these tasks.

Foreign-source uses should be reported to the next higher level of acquisition management, such as the Program Executive Office, and foreign-source uses common to more than one system identified. At the DoD level, dependencies common to more than one service can be identified. For example, the Army Tactical and Patriot Missile Systems may be dependent on the same foreign-made electronic element as some Navy missile systems. A database should be established to provide consolidated information to all levels of acquisition management. The appropriate level of action for a particular dependency should be at the level of pervasiveness of that foreign-made item. In the above example, DoD's industrial specialists should direct any actions necessary, because the foreign-source dependency involves more than one of the services.

B. DEFINING AN UNACCEPTABLE FOREIGN-SOURCE DEPENDENCY

1. Conclusions

In addressing the question of what constitutes an unacceptable foreign-source dependency, the level of acquisition management and timeframe must be considered. In the short-term, a PM is concerned with the flow of production and/or supporting a fielded weapon system. In the long-term, Army and DoD officials are concerned with maintaining technological superiority of the armed forces.

To a PM, a foreign-source dependency is unacceptable when the credible possibility exists that a foreign source, government, or business, may delay, or deny production-essential items in order to influence, manipulate, or blackmail the Government or U.S. businesses. From DoD's perspective, a foreign-source dependency is unacceptable when; (1) another nation is relied upon for critical items used in the manufacture of essential materiel, or for technologies required to ensure U.S. maintenance of its armed forces' technological superiority, and (2) no adequate domestic

source exists, or the Government cannot control emergency production and support through federal laws.

There are numerous tools available for evaluating foreign-source dependencies. The TASC methodology is a superior evaluation method for use at the Army and DoD levels, because of its screening process and quantitative analysis. The PM evaluation methodology presented by DSMC is appropriate for PM's. However, the PM method lacks a quantitative measure of foreign-source dependencies that would enable comparative and trend analyses at all levels.

2. Recommendations

DoD should ensure that a working definition of what constitutes an unacceptable foreign-source dependency be widely disseminated to all levels of Government acquisition management and the defense industrial base. A clear, defense-wide policy on applying the exceptions to full and open competition authorized in the FAR should be distributed.

The Army and DoD should adopt the TASC methodology in their analyses of foreign-source dependencies. PM's should aggressively use the PM evaluation method in conjunction with a definitive quantitative measure, for their examinations of foreign-source use. A variant of the TASC method, tailored for PM use, would meet the need for a quantitative measure and be compatible with higher-level methodologies. A two-directional information flow would keep the acquisition community aware of the current status of dependencies and increase command emphasis on the issue.

C. POLICIES, DIRECTIVES AND GUIDANCE

1. Conclusions

An abundance of directives and policies exists on maintaining a healthy industrial base, along with some specific guidance on foreign-source dependencies. However, both a lack of awareness and an inadequate sense of urgency appear to be obstacles concerning this issue.

The President's Executive Order of June 3, 1994, suggests that the issue is getting attention at the national level. The Order focuses on requirements and responsibilities in

regard to industrial preparedness issues, including foreign-source dependencies. DoD Directive 5000.2 clearly states DoD's policy on foreign-source dependencies. In addition, other DoD Directives and Instructions concerning industrial preparedness support the overall policy. The FAR details the conditions and requirements for exempting contracts from full and open competition. The DPA, including the Title III provisions and DPAS, provides effective tools for keeping American industry capable of supporting DoD in an emergency.

2. Recommendations

The leadership within the acquisition community must raise the awareness of the foreign-dependency issue. The acquisition community should be informed that the current threat environment, and the possibility of future conflicts occurring with little notice, make foreign-source dependencies a critical issue. The past norm of assigning foreign-source dependencies a secondary priority can no longer be tolerated. In addition, practices contrary to existing policies, such as the reluctance to seek exceptions to full and open competition when appropriate, must be removed.

D. VISIBILITY RECEIVED FROM PROGRAM MANAGERS

1. Conclusions

PM's generally have little visibility beyond their first-tier subcontractors and other key vendors. Normally, visibility down to the lower tiers occurs only when a problem arises. Foreign-source dependency matters tend to have secondary priority compared to design, cost, schedule and performance. In addition to a lack of command emphasis, PM's have limited resources to accomplish their many objectives.

2. Recommendations

Adequate resources to examine foreign-source use should be given to PM's, and the issue given equal priority as cost, schedule and performance. Acquisition officials must become more aware of the foreign-dependency issue and be well prepared to identify, evaluate and manage foreign-source dependencies and their associated risks.

Increased emphasis should be allotted to foreign-source dependency issues in professional education courses.

PM's should aggressively address the foreign-source dependency issue throughout a system's acquisition process. Attention given to the issue early in the development of a system, such as during the design and the formation of a manufacturing strategy, could have a substantial impact on reducing the amount of unacceptable foreign-source dependencies.

E. CAUSES OF FOREIGN-SOURCE DEPENDENCIES

1. Conclusions

It appears that national defense is becoming a secondary priority for Government support of R&D. An apparent trend indicates that the emerging focus for Government programs has, instead, been to support R&D aimed at increasing U.S. industrial productivity and competitiveness. In addition, DoD has had to rely on the private-sector for advances in defense technologies. This threatens the long-term technological superiority of U.S. weapons and could increase reliance upon foreign technological advances.

Spending on commercial R&D is increasing, but trails behind gains in production. In spite of legislation aimed at increasing private-sector R&D toward critical technologies, less than half of commercial R&D expenditures were devoted to these pursuits. This will contribute to increased reliance on foreign technological advances.

The production of complex weapon systems requires sophisticated, expensive manufacturing equipment. There are inadequate incentives to encourage defense firms to make the long-term capital investments necessary to drive down costs and improve quality. The higher costs of domestic products reduce America's competitiveness.

Higher costs due to the lack of capital investment, or other reasons, such as labor and overhead, have been the most noted cause of foreign-source use. As a result of lower labor costs, higher productivity and better manufacturing technology foreign firms

have successfully competed with U.S. firms. Often, foreign competition has driven domestic firms out of business, or into producing another product.

The chronic defense industrial base problems which are still present, such as the higher cost of capital, longer returns on investment, and the unique problems associated with doing business with the Government have been barriers to entry for other domestic firms. Thus, foreign firms compete with a smaller number of domestic businesses.

The high cost of capital equipment has also caused a growing number of firms from different nations to enter into strategic alliances in order to pool resources. Trade between allied businesses has become a major part of overall international commerce. An increasing number of alliances source a significant share of their parts through international channels, and many have located major production facilities in foreign countries.

The reductions in the defense budgets have caused a shrinkage of the defense industrial base and an increased reliance on FMS to keep production lines operating. The reduced subcontractor base decreases the availability of domestic sources for defense items. Foreign sources are often required to be used as a result of offset agreements that are a part of FMS programs.

The Government and prime contractors' neglect of the subcontractor and vendor base has allowed the problem to progress as far as it has. A traditional philosophy of relying on market forces to dictate the structure of the defense industrial base has been the basis for this neglect.

2. Recommendations

The Government should adopt a strategy of allocating R&D funds according to the degree of usefulness to DoD. The first priority for funding should go to projects with high defense payoffs, but with little or no commercial value. The lowest priority should go to those projects with a dual-use potential. Foreign nations should be allowed to participate in advanced technology programs as long as all R&D is performed in the United States.

The Government should explore options to provide incentives for capital investment in industries that produce defense materiel. Lessons learned from past Government attempts to provide incentives for capital investments may provide useful insights.

Domestic origin of products must be required when an unacceptable foreign-source dependency exists. Preserving America's domestic capacity to support and sustain its armed forces when engaged in two nearly simultaneous MRC's, and to maintain its long-term technological superiority should be equal, if not higher, in importance to maintaining a free market economy. Policies and directives should clearly and aggressively reflect this philosophy.

F. RECOMMENDED AREAS FOR FURTHER RESEARCH

Although an abundance of literature exists on the foreign-dependency issue, there are many areas of research that could be beneficial to the acquisition community. The following areas for further research are recommended:

- The development of a methodology for Program Managers to measure and report the foreign-source dependency of a weapon system
- The examination of the required elements of information needed to create a standard DoD database on foreign-sourced items and technologies
- The performance of a cost-benefit analysis of available, and proposed, contracting options, or clauses, which can be used to control foreign-source dependencies.

APPENDIX A. DOD CRITICAL ITEMS LIST - MISSILES

<u>ITEM</u>	TECHNOLOGY		PROCESS	
	<u>MISSILE SYSTEM</u>	<u>INDUSTRY STATUS</u>	<u>MISSILE SYSTEM</u>	<u>INDUSTRY STATUS</u>
1. Infrared/Radar Domes	Y	NA	Y	NA
2. Warheads	Y	NA	Y	NA
3. Safe and Arm Devices	Y	NA	Y	NA
4. Rocket Motors	Y	NA	Y	NA
5. Control Actuation	Y	NA	Y	SA
6. Thermal Batteries	Y	NA	Y	NA
7. Composites	Y	SA	Y	SA
8. Microwave Devices	Y	NA	Y	SA
9. Traveling Wave Tube Amplifiers	Y	SA	Y	SA
10. Infrared Detectors	Y	NA	Y	NA
11. Very High Speed Integrated Circuits/Application-Specific Integrated Circuits	Y	A	Y	A
12. Multichip Modules	Y	A	Y	A
13. Microwave Integrated Circuits/ Millimeter Integrated Circuits	Y	NA	Y	SA
14. Fiberoptics	Y	A	Y	A
15. Displays	Y	A	Y	A
16. Counter Stealth Technology	Y	NA	Y	NA
17. Image Processing	Y	NA	N	A
18. Homing Guidance	Y	NA	N	A
19. Autopilots	Y	SA	N	A
20. Electronic Counter- Countermeasures	Y	NA	N	A
21. Data Fusion	Y	NA	N	A
22. Simulation/Modeling	Y	SA	N	A
23. ADA Software	Y	NA	N	A
24. Supercomputers	Y	A	Y	A

Y = YES N = NO

NA = NOT AVAILABLE

SA = SOMEWHAT AVAILABLE

A = AVAILABLE

APPENDIX B. MISSILE BASE OUTLOOK MATRIX

ITEM	COMPANY	BASE STATUS				FY88	FY89	LOW FINANCIAL RISK
		FY85	FY86	FY87	FY88			
ATTACKS	LORAL	W	W	W	W			
AVENGER	BOEING	W	W	W	W			
HELLFIRE I	ROCKWELL	W	W	W	W			
HELLFIRE II	MARTIN MARIETTA	D	D	W	W			
HELLFIRE, LONGBOW	WESTINGHOUSE/							
JAVELIN	MARTIN MARIETTA	D	D	W	W			
	TEXAS INSTRUMENTS							
MILIS LAUNCHER	MARTIN MARIETTA							
MILIS ROCKET	LORAL	W	W	W	W			
MILIS SADARM	LORAL	D	D	W	W			
PATRIOT LAUNCHER	RAYTHEON	W	W	W	W			
PATRIOT MISSILE	RAYTHEON	W	W	W	W			
PATRIOT RADAR	RAYTHEON	W	W	W	W			
STINGER MISSILE	HUGHES	W	W	W	W			
TOW LAUNCHER TUBE	RAYTHEON							
TOW MISSILE	MATRIC	W	W	W	W			
	TELEFLEX							
	HUGHES							

W = Warm Base - There are production deliveries or procurements in that fiscal year

D = Developmental Item - Not yet in production

UNK - Unknown - Information unavailable

X - Multiple Sources - More than one known producer for the item

X - Similar Commodities - Manufacturer produces similar commodities

X - Government Reliance - Defense contracts less than 50% of firm's business

X - Financial Risk - Company financial risk is low

APPENDIX C. VENDOR SURVEY RESULTS

What percentage of your production goes for defense-related work?

< 25%	33
25-50%	0
51-75%	0
76-100%	0

Using your present sources and equipment, by what percentage and timeframe could your firm increase production in a national emergency?

	1-2 Months	3-4 Months	5-6 Months
< 25%	33	3	0
26-50%	0	28	11
51-75%	0	2	12
76-100%	0	0	10

Does your company use foreign sources (defined as outside North America) sources for items used in your production?

Yes	No
31	2

How many countries are represented in foreign supplier base?

None	2
One	2
2 to 4	7
5 to 6	21
> 10	1

What country has the largest number of your foreign sources?

Japan	9
South Korea	11
Taiwan	2
Denmark	1
Netherlands	1
Singapore	1
Hong Kong	1
Philippines	1
Unknown/No Answer/ Data Not Available	6

If your firm uses foreign sources from more than one country please indicate where the four largest sources which provide the largest dollar value of production inputs to your firm are located and what percentage of your foreign-made inputs they provide.

	Largest	2d	3d	4th	Total	Percentage
Australia		1			1	1.03
Denmark	1			1	2	2.06
France			1		1	1.03
Germany		1	1	2	4	4.12
Hong Kong	1	2	1	1	5	5.15
Italy		1		1	2	2.06
Japan	9	6	8	5	28	28.87
Netherlands	1			1	2	2.06
Philippines	1		1	1	3	3.09
Singapore	1	2	2	1	6	6.19
South Korea	11	8	7	7	33	34.02
Taiwan	2	1	1	1	5	5.15
Thailand		2	1	1	4	4.12
U.K.		1			1	1.03
No Answer					6	
<25%	27	25	23	22		
26-50%	0	0	0	0		
51-75%	0	0	0	0		
76-100%	0	0	0	0		

If you lost your largest foreign supplier, is there a domestic supplier available within 30 days (cost and qualifying components to Government specifications not being consideration)?

Yes	No	Don't Know
27	2	4

What reason(s) prompted your firm to use foreign sources?

The superior quality of foreign-made products	0
The lower cost of foreign-made products	15
The unavailability of domestic sources	8
Other. Explained below	
Offset Agreements	3
Contractual Obligations	2
No answer/Don't Know/Data not available	5

Does your firm provide information to DOD agencies on the use of foreign sources?

Yes	No	No Answer
30*	0	3

*When requested (2 responses)

Does your firm provide information to on the use of foreign sources to defense contractors that purchase your products?

Yes	No	No Answer
30*	0	3

*When requested (2 responses)

If North America were cut off from overseas sources would you experience difficulties in any of the following areas?

No Problems	11
Problems in getting subcomponents and materials.	9
Problems in accessing overseas production processes.	7
Problems in repairs of foreign-made machinery.	2
Other. Explained below.	
Transportation in U.S.	7
Quality of domestic items.	2
No Answer	1

Do you feel that the use of foreign sources for defense-related production is a threat to national security?

Yes	No	No Opinion
	32	1

Please add any comments that you feel would be helpful in researching the use of foreign-made items in the production of defense materiel.

Comment	No. of Responses
Purchase off-the-shelf; no defense-specific parts	2
Foreign sources vary over time, consists of package vendors, assembly vendors and wafer vendors.	1

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